Implementation Guidance for C-ITS Services with Infrastructure Involvement

Deliverable 6 of sub-activity 4.4

(Cooperative ITS Services Deployment Support)

Deliverable title as identified in the EU EIP Grant Agreement:
Deployment guidance for C-ITS services with infrastructure involvement

Version: 1.0

Date: 30th of December 2021

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

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Distribution

Date	Version	Remarks / Dissemination
19.08.2019	0.1	First ideas for a planned update of D2
07.10.2019	0.2	Structure for the planned update
06.03.2020	0.3	Structure with introduction and example topics
02.08.2020	0.4	Inputs sub-chapters: Basic Principles and Cooperation levels
02.11.2020	0.5	Inputs chapters 2 and 4
09.12.2020	0.5.1	Inputs chapters 1 and 2
13.01.2021	0.6/0.6.1	Inputs chapters 1 and 4
25.01.2021	0.6.2	Clean up
25.02.2021	0.6.3	Changes according to comments and small additions chapter 1
09.04.2021	0.6.4	Inputs chapters 4 and 7
15.04.2021	0.6.5	Re-arrangements and layout changes before WebEx meeting
14.05.2021	0.6.6	Inputs chapters 5 and 6, clean-up
27.05.2021	0.6.7	Re-arrangements and layout changes before WebEx meeting
01.07.2021	0.6.8	Chapter 4.6 and comments to chapters 4 to 7
09.07.2021	0.6.9	Insert chapter 8, minor updates
30.07.2021	0.6.10	Update chapter 2, minor updates

29.08.2021	0.7	Re-arrangements and layout changes before WebEx meeting
21.10.2021	0.7.1	Clean-up, resolve comments
11.11.2021	0.7.2	Insert chapter 9, update chapter 4, 8
19.11.2021	0.8	Full clean-up
09.12.2021	0.9	Review of sub-activity members included
30.12.2021	1.0	Document finalized.

Preface

EU EIP

The EU ITS Platform (EU EIP) is the place where National Ministries, Road Authorities, Road Operators and partners from the private and public sectors of almost all EU Member States and neighbouring countries, cooperate in order to foster, accelerate and optimize current and future ITS deployments in Europe in a harmonized way. In order to foster cooperation and the necessary consensus between EU Member States, the EU ITS Platform will facilitate the establishment of a commonly understood state of the art and promoting the actual take-up of EU specifications, guidelines, best practices and/or methodologies.

Sub-activity 4.4: Cooperative ITS Services Deployment Support

Sub-activity 4.4 aims at developing and providing deployment guidance to road authorities and operators on Cooperative ITS (C-ITS). It capitalizes on the results of preceding C-ITS-related activities developing a mechanism for setting up deployment guidance for road operators concerning C-ITS services. It aims at collecting and updating the lessons learned from recent pilots and deployment initiatives as well as at advising and guiding road operators and road authorities in dealing with potential implementation issues concerning C-ITS. In particular, business and operating model implications of C-ITS for all relevant stakeholders and hybrid communication concepts have been examined.

This deliverable

A number of actors in Europe deal with the implementation of C-ITS. They address strategic issues on a range of topics, such as technical, organizational, legal, etc. Other parties carry out pilot implementations on a national and/or cross-border level.

This deliverable updates Deliverable D2 – the basis for a “handbook” addressing road operators and road authorities, especially those who are new to the “C-ITS world”. But it also comes with a new structure and approach and includes new aspects. It provides an overview about the main idea of C-ITS and gives orientation in the process of implementing C-ITS services. Always with the aspiration to guide the reader to relevant documents, actors and projects at European level concerning the implementation of C-ITS on a strategic level.

List of Acronyms and Abbreviations

Abbreviation	Explanation
3GPP	3rd Generation Partnership Project (consortium of telecommunication standard development organisations ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC)
5GAA	5G Automotive Alliance
AA	Authorization Authority
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
C2C-CC	Car-to-Car Communication Consortium
CA	Certification Authority
CACC, C-ACC	Cooperative Adaptive Cruise Control
CAM	Cooperative Awareness Message
CBA	Cost-Benefit Analysis
CBR	Cost-Benefit Ratio
CCAM	Cooperative, Connected and Automated Mobility
CCMS	C-ITS Security Credential Management System
CEN	European Committee for Standardization
C-ITS	Cooperative ITS
C-ITS-S	Central ITS Station
CP	Certificate Policy
CPOC	C-ITS Point of Contact
C-V2X	Cellular V2X (3GPP standard for V2X communications)
DENM	Decentralized Environmental Notification Message
EA	Enrollment Authority
EC	European Commission
ECTL	European Certificate Trust List
ETSI	European Telecommunications Standards Institute
ETSI EN	ETSI European Standard
ETSI TR	ETSI Technical Report
ETSI TS	ETSI Technical Specification
GDPR	General Data Protection Regulation
HLN	Hazardous Location Notification
I2V	Infrastructure-to-Vehicle Communication

IEEE	Institute of Electrical and Electronics Engineers
ISAD	Infrastructure Support Level for Automated Driving
ISO	International Organization for Standardization
ITIL	Information Technology Infrastructure Library
ITS	Intelligent Transport System
ITS G5	European profile standard for communications in the 5 GHz band (based on IEEE standard 802.11/802.11p)
ITSM	IT service management
IVIM	Infrastructure-to-Vehicle Information Message
IVS	In-vehicle Signage
MAPEM	MAP (topology) Extended Message
OBU	On-board Unit
P-ITS-S	Personal ITS Station
PKI	Public Key Infrastructure
R-ITS-S	Roadside ITS Station
RfC	Request for Change
ROI	Return on Invest
RSU	Roadside Unit
RWW	Road Works Warning
SAE	SAE International (formerly Society of Automotive Engineers)
SI	Signalized Intersection
SP	Security Policy
SPaT; SPATEM	Signal Phase and Timing (Extended Message)
SREM	Signal Request Extended Message
SSEM	Signal Request Status Extended Message
TLM	Trust List Manager
TMC	Traffic Management Center
V-ITS-S	Vehicle ITS Station
V2I	Vehicle-to-Infrastructure Communication
V2N	Vehicle-to-Network Communication
V2P	Vehicle-to-Pedestrian Communication
V2V	Vehicle-to-Vehicle Communication
V2X	Vehicle-to-Everything Communication
VMS	Variable Message Signs

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Introduction

About EU EIP and the C-ITS activity

The EU ITS Platform (EU EIP) and its predecessor studies (most recently European ITS Platform (EIP), European ITS Platform (EIP+)) form a collaboration area between road operators on the strategic road network in Europe. Bringing together 26 beneficiaries from 15 EU Member States it is perceived as the European ITS technical knowledge management center. EU EIP involves, same as predecessor studies, an activity on C-ITS services deployment support (sub-activity 4.4).

EU EIP collaborates with key actors for C-ITS deployment from various sectors – policy as well as industry – in order to establish a sound basis for the deployment of initial C-ITS services. The collaboration comprises the institutions of the European Commission (e.g. DG MOVE and other DGs, ITS Committee and C-ITS sub-group, C-ITS Platform, CCAM Platform, CINEA as funding agency, Joint Research Center) as well as umbrella organisations from automotive industry and infrastructure organisations. The state-of-play concerning the cross-actor collaboration is laid down in more detail in D1 of this sub-activity. D2 serves as an early basis for this deliverable (D6) with the examination of the major implementation aspects and C-ITS stakeholders. The White Paper on C-ITS service implementation (D3) gives an overview on C-ITS topics with focus on the road operator's roles and responsibilities. D4 and D5 report on the C-ITS workshops co-organised by this sub-activity. D7 and D8 look ahead: Based on existing roadmaps concerning C-ITS deployment from other organisations, D7 sets a strategy from road operator's viewpoint and D8 condenses the recommendations to road operators for successful deployment of C-ITS services in the next years.

EU EIP Sub-Activity 4.4: Achievements and Deliverables (D1-D8)

The C-ITS activity in the EU EIP study broadly comprises three tasks (activity areas) which are listed below:

- Functional interoperability of C-ITS deployments across TEN-T corridors,
- Deployment guidance for C-ITS services with infrastructure involvement,
- Preparing for C-ITS based services as part of regular operation.

About this deliverable

This deliverable addresses the thematic area of the second bullet point. On the one hand, this deliverable offers an introduction into the topic of Cooperative Intelligent Transport Systems (C-ITS). This introduction is given from the perspective of road operators and highlights their challenges and benefits from implementing C-ITS services – also compared to existing means of traffic management.

On the other hand, this deliverable aims to share the most important experiences from completed and ongoing projects at different stages of implementation of various C-ITS services – collecting and preserving the wealth of expertise that has been built up.

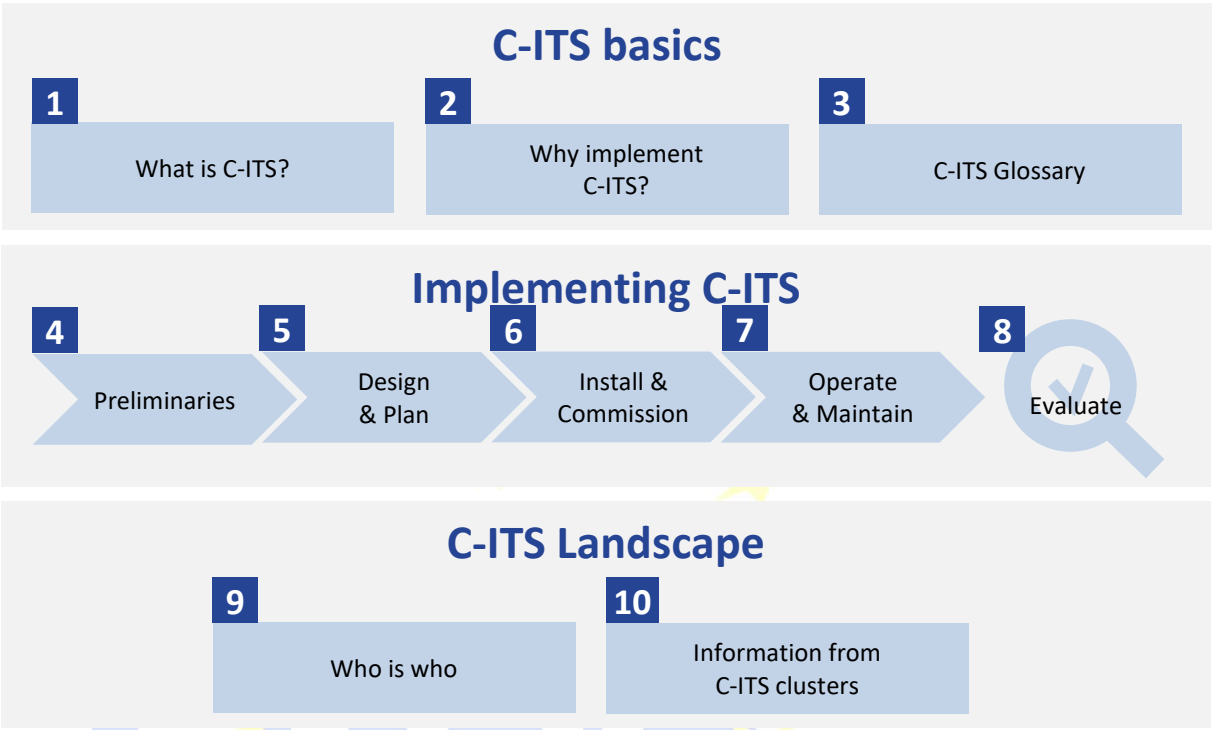

Figure 1: Structure of the contents of this deliverable.

The structure is based on the division of these aspects and is shown in Figure 1. The first part contains the **C-ITS basics**. Chapter 1 starts with giving a first impression of the idea of C-ITS and shows where a road operator comes into play. Chapter 2 focuses on the question why a road operator should implement C-ITS services. It shows how C-ITS services can complement the existing means of traffic management with the corresponding benefits and challenges. Chapter 3 provides a glossary with short explanations of the most important C-ITS terms.

The second part is a repository of important experiences in the different **stages of implementing C-ITS services** explained in short format, partly referencing to relevant documents and specifications. The four stages cover the preliminaries – what should be considered before deploying C-ITS services (chapter 4), the design and planning phase (chapter 5), installation and commissioning of the service (chapter 6), the operation and maintenance (chapter 7) and finally the evaluation (chapter 8).

Further background information is provided in the third part. It starts with an overview of actors in the European **C-ITS landscape** – the Who is Who in chapter 9. Chapter 10 lists and shortly describes relevant information sources within the different C-ITS clusters in Europe. Further overviews are given in the annexes.

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1. What is C-ITS?

As the prefixed “C” indicates, C-ITS emerged as a new dimension of traditional Intelligent Transport Systems (ITS). Traditional ITS typically use fixed hardware installed on and around the roads as sensors and actuators. These systems react dynamically on changing measured sensor values either with manual, automated or partly automated operation. Road users receive appropriate signals, traffic regulations and driving recommendations through displays, other signal devices or via radio broadcast with a navigation system.

The “C” dimension has taken into account the evolving technologies that enable a continuous and real-time exchange of information between all relevant actors on and along the roads. Moving road users communicate with each other and also with fixed devices at the road side. Cooperation could start on a small scale with simple messages to inform other participants in road traffic starting today and could go as far as imagining fully automated road traffic with vehicles moving according to one single common strategic plan in a more distant future.

Cooperation is based on communication. For road operators and road authorities, this opens a wide range of new opportunities: On the one hand, it offers a new way to provide road users collectively with information as in well-established applications and processes. On the other hand, prospectively, new ways of traffic management are imaginable through receiving much more real-time data from vehicles, enhancing knowledge about the state of traffic and road infrastructure and providing single road users with specific purposive information for enhanced traffic management at micro and macro levels. So in future, information exchange in road traffic will not be a one-way street anymore but rather a bidirectional communication of partners on eye level following the same objectives.

This chapter is intended to provide the most important basics for entering the world of C-ITS. After describing the basic concept of C-ITS from the point of view of an infrastructure operator in Section 1.1 expanding on the basic thoughts already mentioned in this introduction, Section 1.2 explains the different ways and technologies of communication. Section 1.3 intends to sharpen the definition and scope of C-ITS, before Section 1.4 concludes the chapter with an outlook on how C-ITS-equipped road infrastructure can support advancing automated driving functions.

1.1. Concept of C-ITS in a Nutshell

Intelligent Transport Systems are systems based on data exchange and therefore enable a more intelligent use of the transport infrastructure. Cooperative ITS (C-ITS) adds the cooperation which requires a commonly understood communication. C-ITS encompass different kinds of communication of vehicles. They could communicate with other vehicles (V2V) and/or with infrastructure (V2I or I2V). Besides that, also communication between vehicles and other road users, using personal devices like pedestrians or cyclists (V2P) and between vehicles and a communication network (V2N) can be distinguished. The whole family is also referred to as vehicle-to-everything communication (V2X).

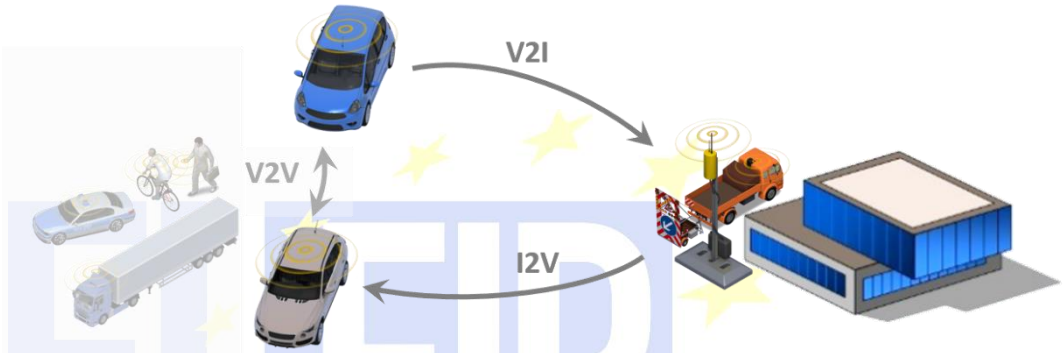


Figure 2: Part of the V2X family – schema of V2I, I2V and V2V. Images: C2C-CC; C-Roads.

Vehicles will increasingly be equipped with on-board units (OBUs), which exclusively serve for communication with other road users and road infrastructure. In addition, the usage of mobile devices is feasible which would facilitate incorporating e.g. vulnerable road users like pedestrians and bicyclists. Road infrastructure is an important player in road transport. In order to join the communication and cooperation network, infrastructure needs to be equipped with roadside units and/or a capable mobile network (see also section 1.2). For road operators, the modes with infrastructure involvement are the most relevant ones within the V2X family. Dedicated info boxes on pages 16 and 17 expand on V2I and I2V.

Vehicles or devices in the vehicle communicate not only directly with each other, but also more and more with backends from car manufacturers and other service providers. Traffic management centres also provide a variety of information, which are ultimately used in the vehicles. Any kind of communication of vehicles is often also called “connected driving” as part of “connected mobility”.

Many of those kinds of communication have been established for delimited use with proprietary standards. As the C-ITS ecosystem is open to any road user, C-ITS communication needs a common language and a common basis of trust. The common language are standardised messages and the basis of trust is built by the Certificate Policy

and the Security Policy. Thus, when talking about C-ITS, this refers exclusively to V2X communication using C-ITS Messages within the C-ITS Trust Domain. These topics are elaborated in section 1.3.

As the prospective possibilities of C-ITS applications are almost endless, the C-ITS Platform defined so-called day-1 services, day-1.5 services and day-2 services in 2016. C-Roads has described all C-ITS use cases already deployed in the C-Roads Member States, cf. info box on page 18.

C-ITS Platform (2016): Final Report

Vehicle to Infrastructure (V2I) Communication

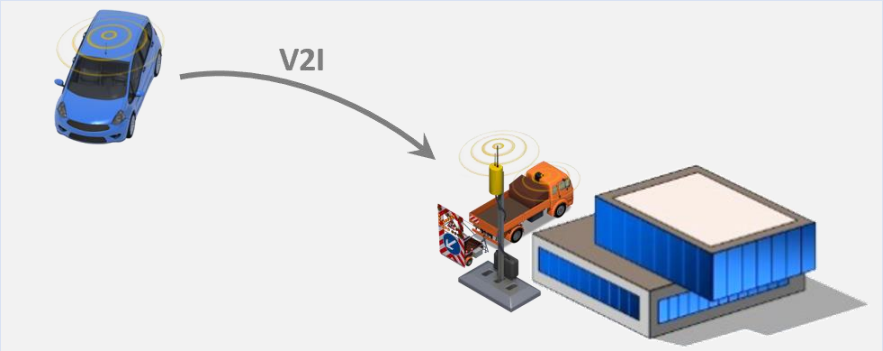


Figure 3: Schema of vehicle-to-infrastructure communication (V2I).
Images: C2C-CC; C-Roads.

Extensive sensor technology in vehicles can extend or (occasionally or prospectively) even substitute the sensors of the road infrastructure. While traditional fixed infrastructure sensors can provide information on the equipped part of the road permanently, connected vehicles can provide information on the frequented part of the road and only at a specific point in time. Hence, V2I information quality depends on the traffic volume.

Available and deployed V2I services:

- Location, velocity, acceleration/deceleration, …, of the vehicle to improve the traffic conditions
- Identified hazardous locations (e. g. triggered by heavy deceleration, weather sensors, ESP, airbags, …)

Future possibilities via V2I – not yet deployed:

- Deviations from expected infrastructure features (corrections of digital map)
- Aims and intentions of the vehicles (tactical and strategic)

Infrastructure to Vehicle (I2V) Communication

Figure 4: Schema of infrastructure-to-vehicle communication (I2V).
Images: C2C-CC; C-Roads.

Already with traditional signage and ITS, road infrastructure communicates with the road users in order to control the traffic flow or to warn the road user. This information can also be transmitted digitally into the vehicle which allows a fast transmission of information to the concerned road user at any time necessary.

Available and deployed I2V services:

- Hazardous Location Notification (HLN)

  Warning of e.g. accident zones, traffic jam ahead, critical weather conditions, slippery roads, obstacles on the road, emergency vehicles or public transport vehicles or wrong way driving.

- Road Works Warning (RWW)

  Information on e.g. lane closures, road closures; warning of mobile road works, winter maintenance or road operator vehicles.

- In-vehicle Signage (IVS)

  E.g. dynamic speed limit information, lane management, shock wave damping.

- Signalised Intersection (SI)

  E.g. signal phase information or prioritisation of special vehicles (partly also V2I).

Future possibilities via I2V – not yet deployed:

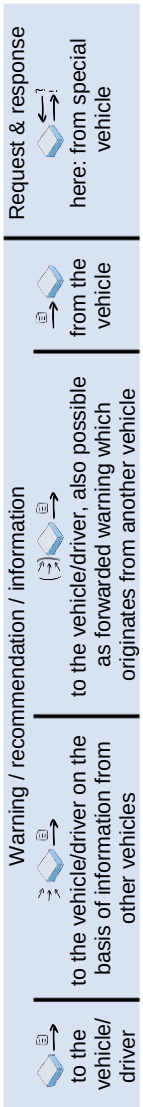
- Reliable (and potentially legally binding) information for automated vehicles
- Extended sensor information of the vehicle (transmission of a dynamic digital map)
- Tactical and strategic recommendations or commands to individual vehicles.
- Commercial services, e.g. advertisements

C-ROADS (2021): Common C-ITS Service and Use Case Definitions

[a] $V_{EV}2V$: Emergency Vehicle to Vehicle
$V_{PT}2V$: Public Transport Vehicle to Vehicle
$V_{RO}2V$: Road Operator Vehicle to Vehicle

[b] see info box p. 21

[c] IA: Types of interaction from the point of view of the infrastructure operator:



C-ITS Use Cases with Infrastructure Involvement

as of "Common C-ITS Service and Use Case Definitions Version 1.8.0 and 2.0.0"

Use Case	Use Case Title	V2I	I2V[a]	Message Type[b]	IA[c]
IVS-DSLI	Dynamic Speed Limit Information	-	I2V	IVIM	
IVS-EVFT	Embedded VMS „Free Text"	-	I2V	IVIM	
IVS-DLM	Dynamic Lane Management	-	I2V	IVIM	
IVS-SWD	Shock Wave Damping	V2I	I2V	CAM | IVIM	
IVS-OSI	Other Signage Information	-	I2V	IVIM	
HLN-AZ	Accident Zone	-	I2V	DENM	
HLN-TJA	Traffic Jam Ahead	-	I2V	DENM	
HLN-SV	Stationary Vehicle	(V2I)	I2V	(DENM) | DENM	
HLN-WCW	Weather Condition Warning	(V2I)	I2V	(DENM) | DENM	
HLN-TSR	Temporarily Slippery Road	(V2I)	I2V	(DENM) | DENM	
HLN-APR	Animal or Person on the Road	-	I2V	DENM	
HLN-OR	Obstacle on the Road	-	I2V	DENM	
HLN-EVA	Emergency Vehicle Approaching	-	$V_{EV}2V$	DENM	
HLN-EVI	Emergency Vehicle in Intervention	-	$V_{EV}2V$	DENM	
HLN-RLX	Railway Level Crossing	-	I2V	DENM	
HLN-UBR	Unsecured Blockage of a Road	-	I2V	DENM	
HLN-AWWD	Alert Wrong Way Driving	-	I2V	DENM	
HLN-PTVC	Public Transport Vehicle Crossing	-	$V_{PT}2V$	DENM	
HLN-PTVS	Public Transport Vehicle at a Stop	-	$V_{PT}2V$	DENM	
RWW-LC	Lane Closure (and other restrictions)	-	I2V	DENM	
RWW-RC	Road Closure	-	I2V	DENM	
RWW-RM	Road Works Mobile	-	I2V	DENM	
RWW-WM	Winter Maintenance	-	$V_{RO}2V$	DENM	
RWW-ROVI	Road Operator Vehicle in Intervention	-	$V_{RO}2V$	DENM	
RWW-ROVA	Road Operator Vehicle Approaching	-	$V_{RO}2V$	DENM	
SI-SPTI	Signal Phase and Timing Information	-	I2V	SPATEM & MAPEM	
SI-GLOSA	Green Light Optimal Speed Advisory	-	I2V	SPATEM & MAPEM	
SI-ISVW	Imminent Signal Violation Warning	-	I2V	SPATEM & MAPEM	
SI-TLP	Traffic Light Prioritisation	V2I	I2V	SREM | SSEM	
SI-EVP	Emergency Vehicle Priority	V2I	I2V	SREM | SSEM	
AVG-SAELG	SAE Level Guidance	-	I2V	IVIM	
AVG-PSI	Platoon Support Information	-	I2V	IVIM	
PVD-VDC	Vehicle Data Collection	V2I	-	CAM	
PVD-EDC	Event Data Collection	V2I	-	DENM	

1.2. Way of communication and technology

So far, it has become clear that communication is the starting point for cooperative systems. As vehicles are most often in motion when communication is useful, an appropriate way of wireless communication is needed for C-ITS. Two fundamentally different ways of exchanging C-ITS messages can be distinct:

Short-range communication (also “direct communication”)

This way of communication requires a dedicated device at sender and receiver to be able to exchange data on a harmonised radio frequency with harmonised specifications. Messages are normally broadcast, as the recipient is not known yet. Anyone can receive messages and ensure its authenticity with a specific certificate as part of the message.

Long-range communication (also “network communication”)

This way of communication uses an existing network with internet access to exchange messages – typically the cellular network or for fixed stations also wire-based networks. The connection is controlled by a service provider, which also ensures authenticity of the participants. Additional authenticity checks of every single message as for broadcast messages are not inhibited.

Hybrid communication

In order to combine the advantages of both worlds, Hybrid Communication means sending the same message with different communication technologies.

	Short-range communication	Long-range communication
Range **of information dissemination**	Short (typically 300-500 m; up to 1 km)	Not limited physically
Coverage **for I2V communication**	Everywhere where RSUs are installed or equipped road-operator vehicles are in service	Where cellular networks exist
Intermediaries	None	Mobile network operator transmits information
Service provision	directly from RSUs or road-operator vehicles to built-in vehicle device	through third-party service provider or road-operator app
Information **from vehicles**	Can be used where RSUs or road-operator vehicles receive information from broadcasting vehicles (respecting privacy)	can be used if the driver transmits information through a road-operator app or if a service provider forwards the information (with user consent)
Available technologies	ITS G5, C-V2X Direct Mode	Existing cellular networks

1.3. Definition and Delimitation of C-ITS: Messages and Trust Domain

To date, there is no commonly and widely acknowledged definition of C-ITS. C-Roads and the Car 2 Car Communication Consortium (C2C-CC) provide high-level definitions:

C-ROADS (2017): Objectives

C2C-CC (2021): About C-ITS

Definition by C-Roads	Definition by C2C-CC
"Being a part of Intelligent Transport Systems, cooperative ITS (C-ITS or cooperative systems) encompass a group of technologies and applications that allow effective data exchange through wireless communication technologies between components and actors of the transport system, very often between vehicles (vehicle-to-vehicle or V2V) or between vehicles and infrastructure (vehicle-to-infrastructure or V2I)."	"Cooperative Intelligent Transport Systems (C-ITS) refers to transport systems, where the cooperation between two or more ITS sub-systems (personal, vehicle, roadside and central) enables and provides an ITS service that offers better quality and an enhanced service level, compared to the same ITS service provided by only one of the ITS sub-systems. […] "

5GAA (2021): Vision and Mission

ETSI (2018): Testing C-ITS

Similar definitions are available e.g. by 5GAA or ETSI. While the definitions mainly describe V2X communication, they do not describe how this communication works. For C-ITS to become an open ecosystem for any road user, two pillars are essential which are described in more detail in dedicated info boxes:

- A common language (page 21) and
- A common basis of trust between all actors (page 22).

In this document, V2X communication is only called C-ITS if it builds on those two pillars.

ETSI (2021): TC ITS

ETSI TR 101 607 (2020-02)

For Europe, the common language has been standardised mainly by the ETSI Technical Committee ITS. ETSI TR 101 607 provides an overview of all ETSI standards and specifications concerning C-ITS. For some message types, references to non-ETSI standards are provided. Profiles of these message types – i.e. specifications how to use the standards – have been developed by C-Roads for the road infrastructure side and by C2C-CC for the vehicle side. Messages and message profiles together are the core of the common language. Dependent on the communication technology, the system profiles include additional specifications (C-Roads, C2C-CC, 5GAA).

C-ROADS (2021): Harmonised C-ITS Specs

C2C-CC (2021): Basic System Profile

5GAA (2020): C-ITS Communication System Profile

The second pillar of C-ITS is the common basis of trust. If messages are exchanged between actors that do not know each other, a mechanism to ensure the authenticity and trustworthiness of the message sender is required. For this reason, the message standards foresee a certificate to be attached to each C-ITS message, which allows the validity of the sender's certificate to be verified. This is also called signing of C-ITS messages. The C-ITS Platform Working Group on Security has published the Certificate Policy (CP) and Security Policy (SP) in 2017.

C-ITS Messages and Profiles – the Common Language

Specific C-ITS messages have been designed to exchange information between C-ITS actors. They are part of the so-called Facilities Layer of C-ITS communication and independent from the communication technology on the Access Layer or Network & Transport Layer. More information on the Communications Architecture can be found in ETSI EN 302 665.

ETSI EN 302 665 V1.1.1 (2010-09)

The following table lists some important standards that specify data elements of C-ITS messages.

Message	Standard	Version
CAM, DENM	ETSI EN 302 637 • Part 2: Specification of Cooperative Awareness Basic Service • Part 3: Specifications of Decentralized Environmental Notification Basic Service ETSI TS 102 894 • Part 2: Applications and facilities layer common data dictionary	 1.4.1 (2019-09) 1.3.1 (2019-04) 1.3.1 (2018-08)
IVIM	CEN ISO/TS 19321: Dictionary of in-vehicle information (IVI) data structures	2020
MAPEM, SPATEM, SSEM, SREM	CEN ISO/TS 19091: Using V2I and I2V communications for applications related to signalized intersections	2019

ETSI EN 302 637-2 V1.4.1 (2019-09)

ETSI EN 302 637-3 V1.3.1 (2019-04)

ETSI TS 102 894-2 V1.3.1 (2018-08)

CEN ISO/TS 19321 (2020)

CEN ISO/TS 19091 (2019)

Profiles specifying how to use these standards are listed in the following table.

Publisher	Name of Profile	Release
C-Roads	Harmonised C-ITS Specifications for Europe: • C-ITS Message Profiles and Parameters • Roadside ITS-G5 System Profile • Mobile Roadside ITS-G5 System Profile	2.0 (2021-08)
C2C-CC	Basic System Profile: • Vehicle C-ITS Station Profile	1.6.0 (2021-07)
5GAA	Initial C-V2X System Profile (Amendments to C-Roads and C2C-CC Profiles for Cellular Uu Interface)	(2020)

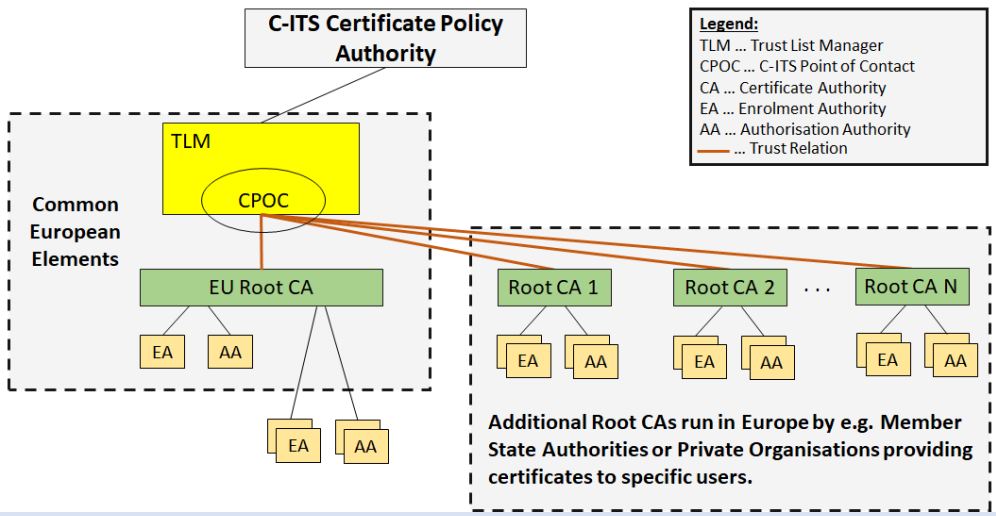
C-ROADS (2021): Harmonised C-ITS Specs

C2C-CC (2021): Basic System Profile

5GAA (2020): C-ITS Communication System Profile

C-ITS Trust Domain – the Common Basis of Trust

In the C-ITS Trust Domain, trust is established with certificates that are attached to each C-ITS message by the sending C-ITS actor. The C-ITS actor receives certificates from an authorisation authority (AA). This is only possible if the C-ITS actor is enrolled at an enrolment authority (EA) of the same Root Certificate Authority (Root CA) as the AA.



The figure shows that all Root CAs connect to the C-ITS Point of Contact, which is part of the Trust List Manager (TLM). Through the European Certificate Trust List (ECTL) of the TLM, the validity of a received certificate of a C-ITS message can be confirmed. The Common European Elements are hosted by EC – the EU C-ITS security credential management system (CCMS).

For ECTL and Root CAs, Levels 0 to 2 have been defined with different security requirements (0: lowest for tests; 2: highest for long-term operation) in the EU CCMS.

Publisher	Name of Document	Rel./Ver.
European Commission	Result of C-ITS Platform Phase II: • Security Policy & Governance Framework for Deployment and Operation of European C-ITS • Certificate Policy for Deployment and Operation of European C-ITS	1 (2017-12) 1.1 (2018-06)
C-Roads	Harmonised C-ITS Specifications of Europe: • C-ITS Security & Governance • C-ITS Security Requirements & Specifications	1.8 (2020-12)
ETSI	Relevant standards listed in C-Roads and EC documents above	

EC (2017): Security Policy & Governance Framework

EC (2018): Certificate Policy

C-ROADS (2021): Harmonised C-ITS Specs

ETSI Overview

1.4. Outlook: Higher Levels of Cooperation and Automated Driving

Current C-ITS deployments focus on the first level of connecting road users with road infrastructure. Since connectivity and cooperation take even greater effect with automated vehicles, this triad is often referred to by the established term CCAM (Cooperative, Connected and Automated Mobility).

SAE J3216 (2021)

In SAE J3216, classes of cooperation have recently been defined and it is shown how the cooperation classes can be used for the established levels of automation defined in SAE J3016:

SAE J3016 (2021)

Class A	Class B	Class C	Class D
Status-sharing	Intent-sharing	Agreement-seeking	Prescriptive
"Here I am and what I see" (e.g. Brake Lights, Traffic Signal)	*"This is what I plan to do"* (e.g. Turn Signal, Merge)	*"Let's do this together"* (e.g. Hand Signals, Merge)	*"I will do as directed"* (e.g. Hand Signals, Lane Assignment by Officials)

INFRAMIX (2018): ISAD Levels

Assuming that automated driving technology will require reliable data from the infrastructure, the European INFRAMIX project defined five Infrastructure Support Levels for Automated Driving (ISAD Levels) that allow a categorisation of road sections in order to indicate the information available to automated driving vehicles from the road infrastructure to the automated driving vehicle:

	Level	Name	Description	Digital information provided to AVs: Digital map with static road signs	VMS, warnings, incidents, weather	Microscopic traffic situation	Guidance: speed, gap, lane advice
Digital infrastructure	A	Cooperative driving	Based on the real-time information on vehicles movements, he infrastructure is able to guide AVs (groups of vehicles or single vehicles) in order to optimize the overall traffic flow	X	X	X	X
	B	Cooperative perception	Infrastructure is capable of perceiving microscopic traffic situations and providing this data to AVs in real-time	X	X	X	
	C	Dynamic digital information	All dynamic and static infrastructure information is available in digital form and can be provided to AVs	X	X		
Conventional infrastructure	D	Static digital information / Map support	Digital map data is available with static road signs. Map data could be complemented by physical reference points (landmarks signs). Traffic lights, short term road works and VMS need to be recognized by AVs	X			
	E	Conventional infrastructure / no AV support	Conventional infrastructure without digital information. AVs need to recognise road geometry and road signs				

2. Why Implement C-ITS?

The notion of C-ITS was first and foremost conceived to improve two key areas which determine the performance of a road network – road safety and traffic efficiency. While these two indicators serve as primordial pillars backing the case of C-ITS, benefits are in effect more diverse and include environmental, operational, and user-related aspects, among others. Section 2.2 provides a contextual overview of such benefits while Section 2.1 presents the maturity of C-ITS which justifies its imminence.

2.1. Maturity of C-ITS

Europe's road network connectivity activities originated more than a decade ago through the agreement to allocate a dedicated 5.9 GHz vehicle-to-everything (V2X) frequency for the establishment of C-ITS (Sjöberg et al., 2017). Since then, remarkable new developments took shape to facilitate C-ITS and still present a tremendous potential to upturn the performance of road networks and the operators responsible of them. While C-ITS' benefits appear to be proportional to penetration rates of connected vehicles, trends suggest that mass deployment of C-ITS in infrastructure-ready regions can be observed by as soon as 2025. In fact, more than 100,000 km of European roads in total are covered by C-ITS services to date (C-Roads, 2021). Additionally, multiple automotive manufacturers are readying their vehicles for C-ITS services with Volkswagen being among the early adopters (Abuelsamid, 2019). The maturity of the technology enables a pragmatic view regarding the associated benefits explored in 2.2 – 2.3, which may be indeed exploited in the coming decade and therefore require transport authorities to fully prepare for its advent.

Sjöberg, Andres, Buburuzan, Brakemeier, 2017. Cooperative intelligent transport systems in Europe: Current deployment status and outlook. IEEE Vehicular Technology Magazine, 12(2), pp.89-97

C-ROADS (2021): Press release.

Abuelsamid, 2019. Volkswagen Adds 'Vehicle-To-Everything' Communications To Revamped Golf With NXP Chips. Forbes.

2.2. Benefits of C-ITS

ROAD SAFETY

Considering that only a few C-ITS services have been introduced and tested at mass scale to date, the road safety component of C-ITS proves to be quite challenging to measure in an accurate manner, despite being an almost guaranteed outcome of such services. Multiple studies worldwide have indeed been undertaken regarding this specific matter and prove time and again a reduced number of road crashes as a result of various C-ITS applications, using field operational tests and associated computer simulations as well as mass crash data. Improved road safety is in fact a main resultant of more attentive and coordinated driving facilitated by such C-ITS services.

Example: C-ITS Service In-Vehicle Signage (IVS)

Description

IVS is an information service to inform road users on actual static or dynamic road signs (or additional information mimicking virtual road signs) via in-car systems. The road signs can be mandatory or advisory.

Expected Benefits

In-Vehicle Signage allows the driver to be informed earlier and more completely by providing continuous signage information directly in the vehicle. This should result in better adaptation to current regulations and traffic conditions.

The primary expected impact is more attentive driving by providing relevant and continuous information on road signage (e.g. speed limits), which improves traffic safety as it eliminates or reduces the severity of accidents.

TRAFFIC EFFICIENCY and ENVIRONMENTAL BENEFITS

Multiple C-ITS services are expected to enable significant improvements in average speed/traffic flow and therefore alleviate congestion. Simulation studies, which consider high penetration rates of C-ITS services by 2030 estimate up to savings of 3% of total time spent on roads for passenger cars and buses in urban areas (Ricardo, 2016). Put into perspective, that equates to about 2 billion hours per year in Europe; a substantial amount of travel time savings and therefore, highly desirable economic benefits when considering the monetary value of travel time. Additionally, an even greater significance is attributed to travel time savings when considering efficiency gains by supply-chain logistics systems (Marotte et al., 2018).

Ricardo Energy & Environment, 2016. Study On The Deployment Of C-ITS In Europe: Final Report.

Travel time savings, reduced congestion, and improved traffic flow and therefore smoother driving result into significant benefits in fuel consumption and associated CO_2-eq. emissions, enabling cities to alleviate transport's impact on global warming as well as citizens to lead healthier lifestyles.

Marotta, Studer, Marchionni, Ponti, Gandini, Agriesti, Arena, 2018. Possible impacts of C-ITS on supply-chain logistics system. Transportation research procedia, 30, pp.332-341.

Example: C-ITS Use Case Greenlight Optimised Speed Advisory (SI-GLOSA)

Description

GLOSA will provide speed advice information to road users for a safe and efficient approach and crossing of a signalised intersection(s). This enables road users to adapt their approach speed and to pass one or more signal-controlled intersections in an energy efficient manner (e.g. by minimizing stops, acceleration and deceleration), safely and sustainably.

Expected Benefits

The expected benefit is a smoother driving behaviour while approaching and driving through a sequence of traffic light-controlled intersections, which reduces stops, reduces emissions and increases safety. Surveys and trials suggest that drivers' behaviour does indeed improve driving style, yielding reduced speed variance. Congestion and vehicular emissions are therefore expected to be minimised as an outcome of the service.

USER ACCEPTANCE and CONVENIENCE

User Acceptance consists of the willingness of road users to adopt in-vehicle C-ITS services and consequently find it desirable and beneficial with respect to their driving style. As such, it assesses the drivers' comfort and convenience in various ways, and seeks primarily to answer the following: irrespective of the safety, traffic, and environmental benefits of C-ITS services, would users perceive any subjective benefit with respect to their driving comfort? Evidence suggests so, inferring that drivers do not only find the information shared with them through the various in-vehicle C-ITS services to be useful, but also express a more relaxed driving style as a result (C-MobILE, 2018).

C-MobILE, 2018: Ex-Ante Cost-Benefit Analysis.

Example: C-ITS Use Case Embedded Variable Message Sign "Free Text" (IVS-EVFT)

Description

The goal of the Embedded Variable Message Sign (VMS) use case is to display to the road user in-vehicle information of type "free text". The information will either reproduce what is displayed at a physical VMS (e.g. variable text panel) or display a completely new message that does not mirror a physical VMS (a virtual VMS). The use case also permits to add details (in preferred language) to existing messages in order to provide more precise and comprehensible information to the road users to achieve the desired behaviour.

Expected Benefits

The use case allows continuous display of information (in the driver's preferred language) in the vehicle compared to the short-term awareness provided by the physical VMS, thus limiting stress for the road user to comprehend the content of the information and react accordingly.

OPERATIONAL BENEFITS to ROAD AUTHORITIES

While the aforementioned benefits are primarily centred around societal aspects, road authorities will inevitably experience operational benefits as a consequence. A key benefit will stem from vehicular data (known as probe vehicle data (PVD)) transmitted to Traffic Management Centres (TMCs) which will enable authorities to improve their oversight of the network and respond faster to road events such as accidents, ghost riders, queues, or unsatisfactory asset conditions (e.g., potholes or road surface friction).

Road authorities will therefore further optimise the capacity of the network to provide a more efficient and proactive road management all while enriching information access to road users.

In the long run, as the penetration rate of connected vehicles gains significance, PVD will enable reducing the cost of traffic data collection as well as reducing or removing infrastructure altogether. As such, economies of scale will be a key principle to consider as investment is poured into new C-ITS services.

Example: C-ITS Service Probe Vehicle Data (PVD)

Description

The PVD service enables road authorities to receive vehicle data and event data from all C-ITS-equipped vehicles. Roadside ITS Stations can receive the broadcast messages and the data can be processed in the Traffic Management Centre in compliance with data protection rules.

Expected Benefits

The PVD service contributes to the improvement of several core tasks of road authorities like e.g. network management, event management, knowledge on road and weather conditions, events and event impact. But also other C-ITS services can be improved with data received with the PVD service like e.g. Hazardous Location Notification, optimisation of signalized intersections or collision risk warning. Moreover, costs can possibly be reduced for the installation/maintenance of detection infrastructure.

ENABLEMENT of AUTONOMOUS DRIVING

C-ITS services will also serve as a solid foundation to various levels of autonomous driving. This is, in part, a consequence of the vehicle-to-vehicle (V2V) communication, which will permit the exchange of high-resolution sensor data among vehicles in almost instantaneous timeframes, permitting autonomous vehicles to plan their motion with more certainty and therefore strengthen their safety measures. In the long run, this implies that autonomous driving may not only be mass deployed in faster timescales than predicted, but also benefit from being safer and more informed agents on the road.

Cooperative Adaptive Cruise Control (CACC) is one of many examples which may, for instance, enhance autonomous driving features. CACC allows vehicles to communicate with one another and form coordinated platoons with narrower headways between one another, which in the case of autonomous driving, reduces the need to solely rely on in-vehicle sensors (cameras/radar/LiDAR) to maintain an optimal headway with neighbouring vehicles.

The same reasoning applies to high-resolution data being communicated between vehicles and infrastructures (V2I/I2V) whereby this data complements the vehicle's sensors in its decision-making process.

Example: C-ITS Use Case Hazardous Location Notification – Stationary Vehicle (HLN-SV)

Description	*Expected Benefits*
The Stationary Vehicle(s) use case warns approaching drivers about stationary/broken down vehicles ahead, which may represent obstacles in the road.	Such information may be used by Advanced Driver Assistance Systems and for various levels of autonomy, informing drivers / autonomous vehicles of the presence of a potential obstacle ahead of the road along with the possible presence of vulnerable road user(s), which may have not been accounted for otherwise. This permits drivers / autonomous vehicles to be more vigilant as to avoid any hazard on the road they may have not perceived.

2.3. C-ITS Benefits Versus Costs

While there is a strong industry consensus on the socio-economic benefits of C-ITS services, which are mainly derived from the safety, traffic, and environmental aspects explored in previous sections (2.2), an important assessment to be undertaken is that of comparing these socio-economic benefits – converted to monetary gains – against the costs associated to enabling the deployment of C-ITS services.

Mitsakis, Kotsi, 2017. Costs and benefits of bundled C-ITS services. The C-MobILE approach. In: Smart Cities and Mobility as a Service.

Drawing from Mitsakis and Kotsi (2017), costs may be recurring and non-recurring. Non-recurring costs reflect the investment costs required to enable C-ITS systems and may be segmented into two key categories: planning and design, and installation. Recurring costs consist primarily of operational and maintenance costs. A non-exhaustive breakdown of both categories is presented by Mitsakis and Kotsi (2017) and can be summarised as follows:

Non-recurring costs

Planning and design include costs associated to:

- Radio survey for analysis of C-ITS coverage considering the two main methods of communication: C-V2X or ITS-G5.
- Generation of high-accuracy maps for specific C-ITS services (e.g. GLOSA).
- Detailed design of C-ITS equipment locations (e.g. roadside units (RSUs) for ITS-G5).
- Deployment plan of C-ITS equipment (e.g. RSUs for ITS-G5).
- System integration and licence costs for C-ITS equipment (e.g. RSUs for ITS-G5)

Installation includes costs associated to:

- On-road C-ITS equipment (e.g. RSUs for ITS-G5).
- Traffic signal controller interfaces for applications that require signal phase and timing (SPaT) data.
- High-accuracy mapping and positioning services.
- Data servers for data collection, processing, and distribution.
- Construction inspections of C-ITS equipment during the build phase.
- Potential temporary traffic control while installing C-ITS equipment (e.g. RSUs for ITS-G5).
- In-vehicle equipment where required.
- C-ITS connectivity with back offices or traffic management centres (TMCs) (e.g. connectivity between RSUs and TMCs) where existing capacity is insufficient to handle C-ITS bandwidth requirements.

Recurring costs

Operations and maintenance include costs associated to:

- Power and communication costs of on-road C-ITS equipment (e.g. RSUs for ITS-G5).
- Security management associated to a C-ITS service.

- Incurred costs on Operations Centres for additional hardware and personnel to monitor system performance.
- Staff upskilling for system operations.
- Monitoring costs including realignment of antennas, reboot of hardware, and other typical checks.
- Potential continuous licence fees and manufacturer support for specific devices.
- Lifecycle renewal of C-ITS equipment depending on equipment lifespan or software requirements.

That said, the adoption of C-ITS services may also enable the elimination of physical and digital infrastructure elements such as gantries or roadside sensors (e.g. weather sensors) which can be replaced by In-Vehicle Signage services or PVD collected through in-vehicle sensors.

Various studies have been undertaken to assess the cost-benefit analysis (CBA) of C-ITS and present highly promising results. Major European projects such as *EasyWay*, *Drive C2X*, and others, conclude that the benefit to cost ratios (BCR) of C-ITS services vary between 1.5 and 7.4 (Ricardo, 2016), which implies that benefits can be as low as 1.5 times greater than costs and as high as seven – an attractive range for investing in such a technology. The width of the range is a resultant of the heterogeneity of C-ITS services deployed, assumptions on infrastructure readiness, communication channels adopted, road penetration rate, and methods of deriving benefits and costs. Hence, an assessment is normally undertaken on a bespoke basis to the context of interest. Nonetheless, it is expected to comfortably score higher than a ratio of 1.

Ricardo Energy & Environment, 2016. Study On The Deployment Of C-ITS In Europe: Final Report.

3. C-ITS Glossary

C-ITS Station

All entities that communicate with C-ITS communication standards are called C-ITS Stations. Types of C-ITS Stations include

- Vehicles which have an On-Board Unit (OBU). This OBU is called Vehicle ITS Station (V-ITS-S);
- Roadside Units (RSU) are Roadside ITS Stations (R-ITS-S);
- Central ITS Stations (C-ITS-S) can be in a cloud or in a traffic management centre;
- Personal ITS Stations (P-ITS-S) can be used in personal devices so that especially vulnerable road users can also profit from C-ITS services.

Hybrid Communication, Short-Range Communication, Long-Range Communication

In the field of C-ITS, Hybrid Communication means the parallel distribution of C-ITS messages on two or more ways of contributions. In most of the cases, the two ways of communication used are the direct short-range communication and the indirect exchange via cellular mobile network (long-range communication) – see also chapter 1.2.

Broadcast

For short-range communications, C-ITS stations broadcast C-ITS messages. This means that all surrounding C-ITS stations will receive the message (and only evaluate it if the message has been sent by a reliable station and if the message is relevant).

Radio spectrum / frequency band

Broadcasting C-ITS messages requires dedicated parts of the radio spectrum, which can be used for transmitting the messages physically through the air. In Europe and the US, frequency bands around 5.9 GHz are reserved for C-ITS services.

C-ITS Trust Domain

Checking the trustworthiness of received broadcast C-ITS messages requires a clever system that is trusted by all participants. All participants in the system need to be involved in this system. The basic principle of such a public key infrastructure (PKI) is also described in chapter 1.3.

C-ITS Services, Use Cases and Scenarios

The terms C-ITS Service and C-ITS Use Case are often used with the same meaning. Nonetheless, the C-Roads documents define only six C-ITS Services (In-Vehicle Signage, Hazardous Location Notification, Road Works Warning, Signalised Intersection,

Automated Vehicle Guidance, Probe Vehicle Data). Therefore, with this usage a C-ITS Service is rather a category of C-ITS Use Cases.

EC (2016): C-ITS Strategy

C2C-CC (2020): Roadmap 2020

Day 1 / Day 1.5 / Day 2 Use Cases

The C-ITS Strategy of the European Commission from 2016 originally defined a set of Day 1 Services and Day 1.5 Services. Day 1 Services were to be ready to deploy in a first phase while for Day 1.5 Services some standards or specifications were still lacking. C2C-CC defines Day 2 Services as upcoming deployment phases: “Day 2 services improve the service quality and share perception and awareness information. Day 3+ adds further sophisticated services like sharing intentions, supporting negotiation and cooperation that paves the way towards cooperative accident free automated driving.“

PART II : Implementing C-ITS

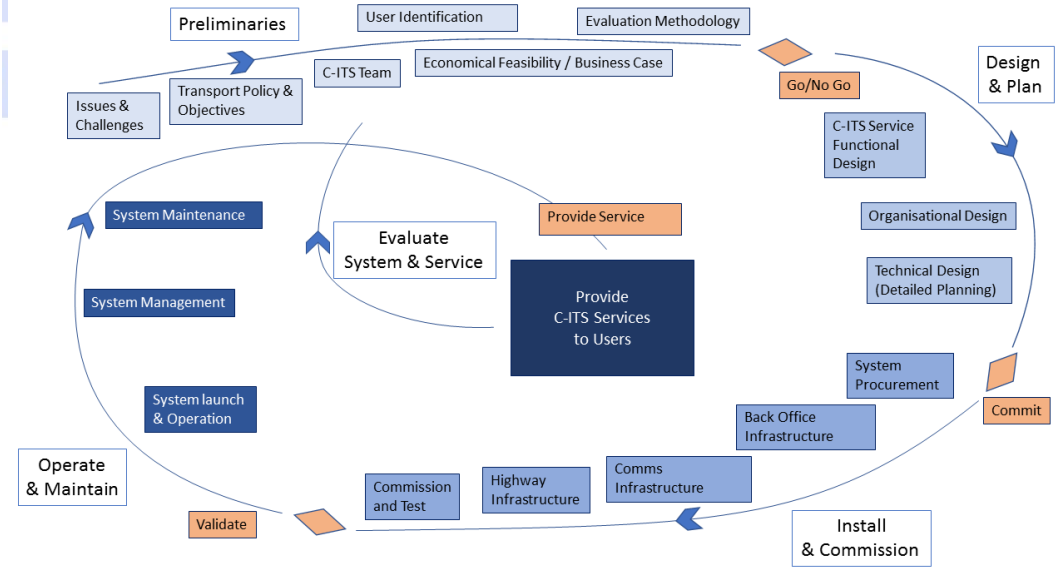
This part of the document is to highlight the key stages which need to be considered and addressed throughout the lifecycle of an implementation project.

The diagram shows the four key stages 1) Preliminaries, 2) Design and Plan, 3) Install and Commission and 4) Operate and Maintain.

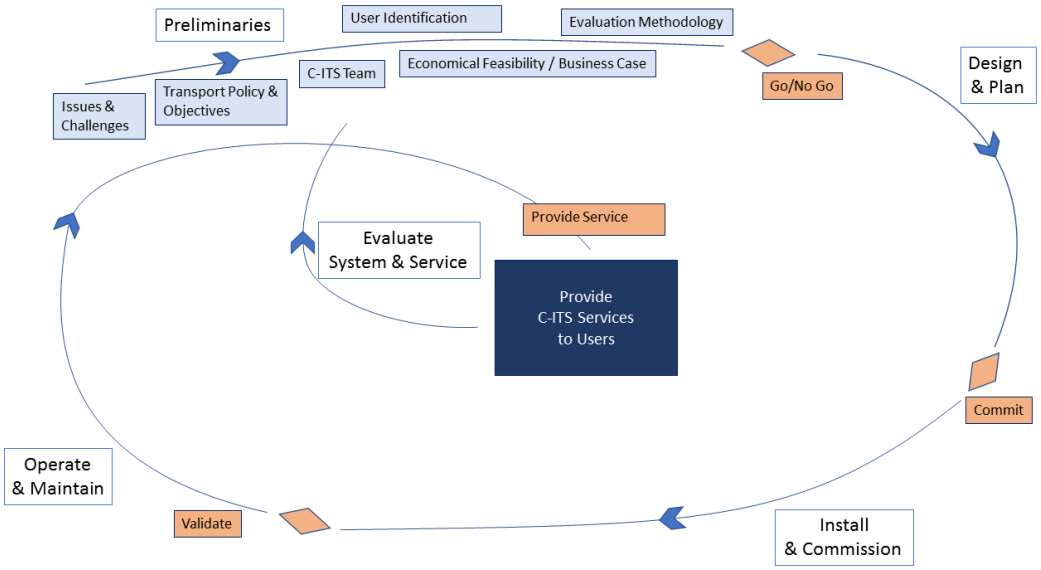
After some time of the following C-ITS service provision to the users, an evaluation of the systems and services should be made (5). Eventually needed changes should go through the lifecycle of the key stages again.

Each key stage is followed by a key decision point:

- Go / no go (based on the outcome of the technical and economic feasibility)
- Commit (to procurement and installation)
- Validate (the systems and services are operating as defined)
- Provide the service.

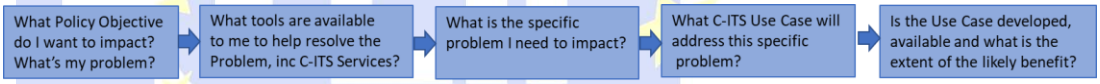


4. Preliminaries – Before C-ITS Deployment



4.1. Overview

In summary, during the preliminary stage of the project the project lead needs to carefully consider the key points in the following diagram.



Once these factors have been considered, the findings will need to be used as inputs to a technical and economic feasibility (sections 4.6 and 4.7). This will help derive the business case with justification to proceed to the detailed design and planning stage (Stage 2).

4.2. Issues and Challenges

Table 1 shows a list of key considerations and issues which need to be explored by the project lead for the scheme during the preliminary stage. Some of these are elucidated in this chapter or elsewhere in this document.

As there is now a wide body of material and advices available, applicable sources have been given to help find information to help address these points. This information has been recently published by organisations such as C-Roads as well as consortia who have promoted pilot C-ITS schemes and have 'learned by doing'.

Developments in methodologies including technical approach are continuing and some of the challenges mentioned below are being or have been largely addressed. In doing so,

they may not necessarily be a significant hurdle or barrier. It is important however, that consideration is given to these key areas during the preliminary stage. More so, in the context of the unique circumstances that will apply in the specific area or jurisdiction where the C-ITS service is to be implemented.

Table 1 – Key Issues and Challenges

Issues to be considered	The challenge	Why is this important?	Useful Information
Understanding the need and problems to be resolved	Is C-ITS the right solution?	Potentially better alternatives within the transport policy context	EU EIP Reference Handbook
Forming the right project team to implement service.	Not a traditional infrastructure project, more a data project	Different skill sets required, different project management approach	
Selecting C-ITS services (use cases) to be implemented	Matching Use case to need and setting priorities	Achieving the best impact and rate of return on investment	See later sections of the report.
Benefit to cost analysis	Justification for investment in a C-ITS service	Prioritisation of financial resources	See later sections of the report.
Business and operational model for ongoing service provision	Complex service chain entities, roles, responsibilities	Multi stakeholder environment and technical systems.	C-ITS Platform Phase II, C-Roads WG1, ISO 17427-1:2018
Key Stakeholders Actors	Complex service chain entities, roles, responsibilities	Collaboration and functional partnerships needed for successful operation	
Cooperation across national and regional borders	Stakeholders across the value chain need to continuously harmonise further developments	Requirements will change over time and new developments have to be integrated	
Project leadership and ownership	Identifying the right lead entity.	Deliverability and accountability	
Operational ownership	Stakeholder responsibility for scheme operation and maintenance	Ongoing availability and quality of service	

EU EIP (2021): Reference Handbook

EC (2017): C-ITS Platform Phase II

C-Roads (2019): WG1 report

ISO 17427-1:2018

Operational overhead	Who pays	Ongoing availability and quality of service	
Measuring impact and level of success	How to evaluate impacts and financial benefits	Investment justification, expansion of the scheme	See later sections of the report.
Legal matters	Governance & Compliance	User acceptance and reputation	C-Roads WG1
Solution technical architecture	Feasibility, Service chain identification	Feasibility, cost and ongoing sustainability	C-Roads WG1
Interoperation and harmonisation	Cross system, user and jurisdiction data sharing	System/service quality and availability	
Data security	Compliance with security framework	User acceptance and reputation	C-Roads TF1
User Privacy	Compliance, User acceptance	User acceptance and reputation	C-Roads WG1,2 , GDPR
Safety matters	Consistency of service in safety related matters	User acceptance and reputation	C-ITS Platform Phase II
Hard infrastructure	Necessity for hard infrastructure	Capex and Opex costs	
Soft infrastructure	Interoperation, vendor tie in, sustainability	Sustainability, Capex and Opex costs	
Technical standards	Compliance with standards	Achievement of interoperation between entities	C-Roads WG2, CEN, ETSI and ISO

C-Roads (2019): WG1 report

C-Roads (2019): TF1 report

EC (2017): GDPR

EC (2017): C-ITS Platform Phase II

C-Roads (2021): Harmonised C-ITS Specs

Further issues and challenges will inevitably arise as the project progresses through the preliminary stage and beyond. The key point is that at the end of the first stage of the project, there should be no significant surprises in the future. Furthermore, that a decision can be made on whether to proceed (or not) to the detailed planning and design stage (Stage 2) using as much factual information as possible.

4.3. Transport Policy and Policy Objectives

- Transport policy sits at **several levels**
- Transport policies are **multi-facetted** and **multimodal**
- C-ITS is **one of many tools** to help meet transport policy objectives
- **Institutional / geographical 'boundaries'** often have to be overcome
- Identify **funding possibilities** for C-ITS infrastructure

A C-ITS service should be implemented to address the objectives of transport policy.

Transport policy sits at **several levels**

At a European level, policy is focused on transport efficiency across the trans-European road network. At a national level, it is likely to be focussed on improving the strategic road network made up of motorways and principal roads. Transport policy will also be instituted at regional and local levels. Each will have different short- and long-term objectives. These policies are often aligned but not always.

References:

European Commission: ITS Action Plan and ITS Directive
(also national ITS reports of the EU Member States available)

European Commission: C-ITS Strategy

Transport policies are **multi-facetted** and **multimodal**

Transport policies are inevitably multi-facetted and multimodal. Because of its inherent connectivity, C-ITS services can support efficiency across other modes but its key benefit will be in improvements to road efficiency, safety and the environment as described in Chapter 2.

References:

European Commission: ITS Action Plan and ITS Directive

C-ITS is **one of many tools** to help meet transport policy objectives

C-ITS as a service is one of many 'tools' that could be used to help meet transport policy objectives. Consequently, implementing a C-ITS service needs to be considered alongside other potential tools and mechanisms that can contribute to or support the achievement of a transport policy objective.

References:

EU EIP: Reference Handbook for harmonized ITS Core Service Deployment in Europe

Institutional / geographical 'boundaries' often have to be overcome

C-ITS services are by nature based on data availability and connectivity, consequently institutional / geographical 'boundaries' and their associated policies can provide a complex backdrop to planning and initiating C-ITS. The 'service chain' will extend beyond the immediate confines of a specific road authority or operator.

Therefore, it is important that at the preliminary stage, the institutional arrangements and policy objectives of each of the stakeholders who will impact and interplay with the proposed C-ITS system are understood.

Key to the successful and beneficial operation of a C-ITS service is identifying how the services will contribute to supporting and delivering policy objectives of each of the layers of institutions whose policies are designed to influence or dictate how transport is delivered on the network. In doing so, the overarching political objectives will be achieved.

During the preliminary stage, it will be important to identify any transport policy that will be relevant to the C-ITS project. Policy objectives, which are often politically determined, will need to be drawn out and understood and areas of commonality listed.

In most cases, a common thread should be identifiable. However, this is not always the case. When this happens, the relevance of the institution and its policy must be re-evaluated for its importance to the project.

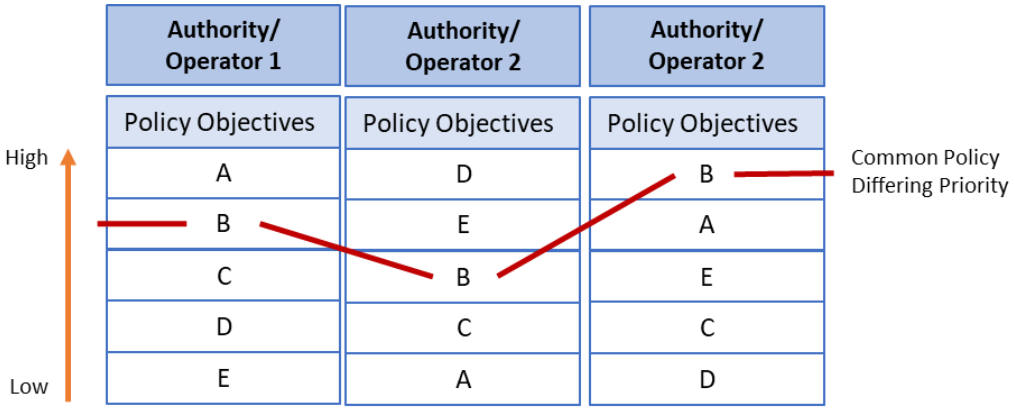


Figure 5: Common Policy Objectives, but Different Priorities.

Figure 5 indicates how a common objective might become evident. Clearly, where commonality is identified, convergence with and between key actors and stakeholders who are responsible for transport policy should be achievable. However, this might not necessarily be simple for any number of reasons, one being differing priorities within each organisation. Furthermore, these policies might be limited to very strict definable geographical areas.

Since a C-ITS service is dependent not only on road authorities and operators, but also on other stakeholders, for instance telecoms providers and other content providers, there is potential for further complexity where the profit motive or market control might become a factor.

Identify **funding possibilities** for C-ITS infrastructure

Given that C-ITS services typically require connectivity with infrastructure, in this case traffic management systems and associated hard and soft infrastructures, public funds will invariable be needed and used to a greater or lesser extent. It might be that a private road operator is responsible for infrastructure. Provision of a service will require financial investment and consequently the rate of return on investment is very likely to be a key question to address during the preliminary stages of a C-ITS project.

Furthermore, it is likely that more than one funding stream will be involved during the implementation and potentially ongoing operation and maintenance stage. This will inevitably increase the complexity of any business model.

References:

-

4.4. C-ITS Team

- Implementing C-ITS is (also) a **data project**
- Consider wisely who **leads** a C-ITS implementation project
- Cover the required **range of expertise**
- C-ITS is a **multi-stakeholder endeavour**
- Required **interoperation** on various levels is complex

Implementing C-ITS is (also) a **data project**

The complexity of implementing a C-ITS service should not be underestimated. Neither should it preclude serious consideration and proceeding with a project. Any transport infrastructure project is complex to initiate and implement. C-ITS will attract a different set of issues and challenges to consider from those for building hard transport infrastructure. For instance, it is unlikely planning authorities will need to be involved. On the other hand, whilst C-ITS will involve a certain amount of hard infrastructure, it is more about data capture, processing and communications. A C-ITS project should be defined as multi-disciplinary - a data project and a 'hard' infrastructure project. Such a project may therefore need a different style of project management and developmental processes.

Consider wisely who **leads** a C-ITS implementation project

A key consideration at the outset must therefore be who is a natural lead for such a project. Traditionally an infrastructure project would be led by the engineering community. Clearly there remains a key role for engineers but the team will need to embody expertise in data systems including data management and communications. Furthermore, expertise for ongoing support and maintenance of electronic systems will be required during ongoing operational delivery of the service.

Cover the required **range of expertise**

It is unlikely that the range of expertise required will reside in one organisation, authority or operator. It is likely that specific expertise will need to be brought in from external organisations or the entire project placed in the hands of a multidisciplinary consultancy.

However the project team might be constituted, the project must remain focussed on the user needs and business outcomes and not become technologically driven despite its importance to successful delivery of the project.

Furthermore, as the C-ITS service will be designed to impact congestion, efficiency, safety and environmental performance, it will be essential to engage with expertise in these specialist areas at the preliminary stage. Insight from these disciplines will be needed to contribute to the feasibility and business case for the project. Additionally, they will be needed following 'go-live' of the project to evaluate and assess the impacts and potentially assist with fine-tuning of the scheme to achieve better outcomes.

C-ITS is a **multi-stakeholder endeavour**

It will be apparent during the preliminary stage that the C-ITS service will remain a multi-stakeholder scheme following 'go-live'. The key point and challenge to understand is that the service might not be under the entire contractual control of one organisation as might be with traditional ITS services. For a C-ITS service, it might be that a road authority holds contracts for telecommunications, and therefore there might be fiscal and qualitative accountability for that part of the service. However, as the C-ITS service relies on multiple data sources outside the direct control of one organisation, and therefore responsibilities and accountabilities might not be clear. For this reason, it will be necessary to establish a business and operating model at the early stages, which takes account of the breadth of involvement of various entities. For quality of service and sustainability, this will almost certainly have to be backed up with some type of formal documentation such as a contract or Memoranda of Understanding or similar, as applicable to the circumstances. These will also need to include qualitative technical specifications.

Required **interoperation** on various levels is complex

As is apparent from the previous paragraphs, perhaps the biggest challenge facing implementation and ongoing operation of the service, is that the C-ITS service will need to interoperate at institutional, managerial, legal as well as technological levels. This

could become more complex as the service expands and encompasses ever-wider jurisdictions. The degree of centralisation of service provision together with its associated technical architecture will be a key consideration during the early preliminary stage.

C-ITS System and Service **Stakeholders**

As highlighted above, promotion, implementation and ongoing operation will involve a large number of stakeholders. Some of these stakeholders could become contractually bound, but others will strongly influence or continue to be involved in service provision and its ongoing quality and success, whether there is direct control or not.

The diagram below provides a useful insight into stakeholders and actors that are likely to contribute to a service. It indicates where policy might reside. Using what is likely to be a typical system architecture involving hybrid communications, it shows the key functions and hence potential entities that might become stakeholders.

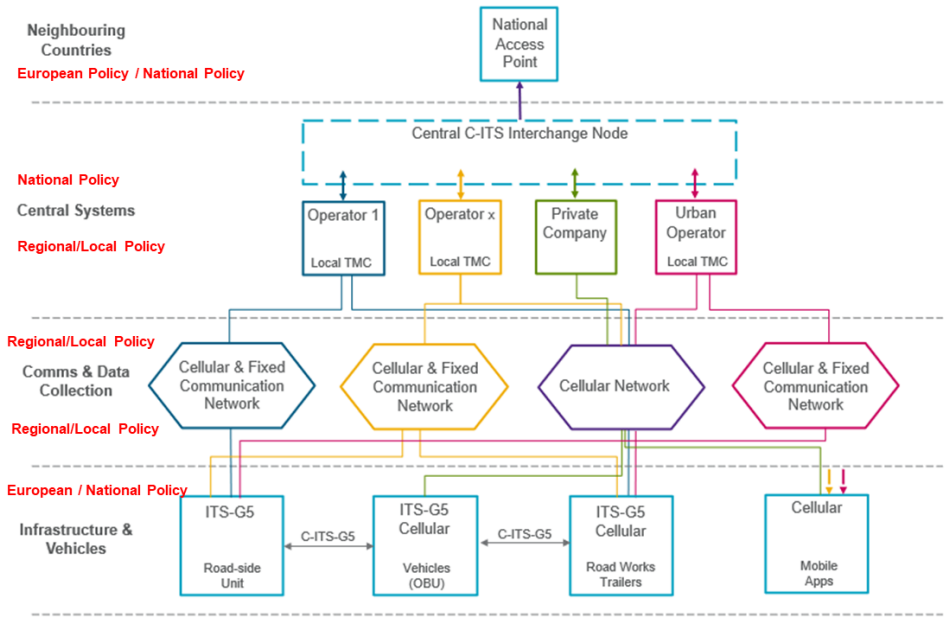


Figure 6: Policy Levels and Potential Technical Service Stakeholders – after C-Roads WG1

The technical architecture will be influenced by the immediate characteristics of the broad location for the service and the data content that might already be available or be required by the use cases to be implemented as part of the service.

Considerable work has been undertaken within C-Roads and during pilot C-ITS system implementation and operation to identify and understand key stakeholders. In Table 2 below, a list is provided that can be used to direct the project lead during the preliminary stages of the project. It also provides advice on where further information can be found. Key stakeholders are those with whom the project lead will need to engage to implement and operate a successful C-ITS service. There will be further background stakeholders who will have influenced or will influence the service through their role in the service or supply chain. These will need to be identified during the preliminary stages.

Table 2: Key Stakeholders

	Role	Why?
National (International) & local policy owners	Targets for road efficiency, safety, environmental performance	The C-ITS service needs to impact these factors to be justified.
Adjacent Road Authorities / Road Operators	Legal entity, potential service lead and owner	Authority, permissions potential funding stream
Traffic Manager(s)	Provision of content derived from road authority/operator traffic management systems/ centre.	Raw content collection, and dissemination.
Content providers*	Provision of real time data as needed by use cases	Raw content collection and dissemination.
National Access Point (NAP)	A NAP can receive and provide data to the service.	Raw content provision and ingestion.
Mobile telecoms provider	Mobile network data carrier	Data delivery to/from devices.
Telecoms provider - other	Fixed and wireless data carrier	Data delivery to/from devices.
3rd Party data aggregator**	Multiple source data processing and distribution	Raw content processing and dissemination.
C-ITS Service Presentation***	Presentation of content to user	Service delivery and fulfilment

*Note: There will be multiple content providers ranging from road authorities to actual C-ITS service users in vehicles and private third parties who might benefit from the service such as road hauliers.

**Note: There are several terms used for this stakeholder role and they will vary depending on the system architecture and types of partners in the service: Interchange Node Operator, C-ITS Service Provider, Central System, C-ITS Back Office are other descriptors.

*** Note: The way the information is delivered to the end user can vary. It could be through embedded or aftermarket (retrofit) systems within vehicles, or on a mobile phone app, or a combination.

During the preliminary stage a stakeholder management plan would be a useful document to guide structured engagement with the stakeholders to ensure individual needs and likely impacts are recorded and properly understood.

4.5. C-ITS Service User Identification and Functional Definition

- Who are the Users?
- Which Use Cases?

During the preliminary stages of the project, it will be necessary to be clear as to who the users of the system and services will be, and which use cases are to be implemented.

Each user will have a set of needs and expected benefits from the C-ITS service. Understanding these will identify the key components and inputs to a business and financial model. This in turn will highlight the expected benefits and derive the CBA in the business case, which will be needed before commitment to the detailed design and planning process. Success in delivering these beneficial impacts can be evaluated after service go-live.

Who are the **Users**?

Primarily, the user is considered to be the driver of a vehicle, regardless of whether it is a commercial or private vehicle. The driver is the key user. However, the nature of C-ITS is to share real time data which will be available, by default to others. The user is therefore not confined to the driver of a vehicle. The user group will potentially comprise:

1. Drivers of vehicles
2. Drivers of special vehicles (emergency, maintenance, public transport…)
3. Vulnerable Road Users
4. Road Authorities
5. Road Operators
6. Public Transport Operators
7. Parking Operators
8. Road Maintainers
9. Logistic companies and fleet managers
10. Value-added resellers of the data/ intermediaries

There may be others depending on the use case selected. Each user will have different requirements, but all will be reliant on the same data. The data might be used in different ways and presented in different forms according to the use case.

Since the implementation of C-ITS services is still at an early stage, it is likely that the user group will be relatively limited. It will grow as different use cases are defined and, in response to user demand, better technologies and ways of using data, become available.

Nevertheless, it is important that the user needs are understood so that the use cases that will meet those needs and deliver the expected benefits are properly selected and incorporated into a business case.

Which **Use Cases**?

A use case describes the function of the system. A user might have a need for information, e.g., about an accident, in a particular situation, e.g., at a location further ahead. The two together describes a use case.

A good deal of work has been undertaken to define and describe use cases. These are described in detail in chapter 1.1 and in publications issued by C-Roads.

Use cases have been broadly clustered under 5 'service headings':

- In-Vehicle Signage (IVS) - is an information service to inform road users on actual static or dynamic road signs (or additional information mimicking virtual road signs) via in-car systems. The road signs can be mandatory or advisory. IVS use-cases will increase road safety and traffic flow efficiency with the potential to eliminate road infrastructure in the long term.
- Hazardous Location Notification (HLN) - This service describes an I2V warning message related to one or a series of potentially hazardous events on the road, where the approaching road users get information and therefore warning about the location and type of hazard they are approaching and – if available – also the duration of the event. IVS use-cases will increase road safety.
- Road Works Warning (RWW) - With this service, warnings are provided to road users about road works, which can be mobile or static, short-term or long-term. Road works are all types of road operations by the road operator including operations and maintenance involving road operator vehicles. RWW use cases will increase road safety and traffic flow efficiency.
- Signalised Intersections (SI) - This service provides information to road users, and vehicle data to traffic light controllers, for a safe and efficient approach and crossing of a signalised intersection(s). The implementation of the infrastructure-based intersection use cases will increase road safety and traffic flow efficiency and minimize environmental pollution at signalised intersections.
- Probe Vehicle Data (PVD) – PVD is a service in which vehicle or road user data is collected by the road operator or service provider. This use case provides efficient access to real-time data to enable the traffic manager to direct traffic in real time. It also provides high quality data for traffic modelling and infrastructure planning.

Within each of the services described above there are several use cases (see also info box on page 18). They are all typified by bringing beneficial impacts to road safety and traffic efficiency. These benefits can be monetised and used as an input into a CBA.

References:

C-Roads (2021): Common C-ITS Service and Use Case Definitions

5GAA (2020): C-V2X Use Cases

4.6. Economical Feasibility - Business Case

Prior to a decision to continue with the project to the detailed planning and design stage (Stage 2) there will be an expectation that a technical and economic feasibility will have been undertaken in the form of a business case.

The conclusion of this work will enable a Go/No Go decision to be made with reasonable confidence, and one that is justifiable to stakeholders including politicians, particularly where public funding is involved. Elements of this work will be able to be evaluated and confirmed once the system is live. This is explained further in chapter 4.7.

Any **business case justification** needs to be pragmatic

The feasibility can take the form of a business case indicating a Rate of Return (ROI) or Cost to Benefit Analysis (CBA). Given C-ITS is a novel service with limited penetration to date, any business case justification needs to be pragmatic in the sense that the value of inputs to the appraisal might not be fully known. To this extent any sensitivity analysis is likely to show a variation which is wider than would normally be expected. This predicament is likely to change as more understanding is gained and more hard data is available concerning the beneficial impacts of C-ITS services.

Compare the intended C-ITS solution with alternative solutions, incorporate user acceptance considerations

The business case will identify the need for the service and should incorporate a comparison with other potential solutions that might meet the same need. The study will also describe how the service might be implemented and operated. Key will be an understanding of the beneficial impacts of the solution. This will be influenced by user acceptance and extent of use of the service, so this should also be factored into the analysis.

Monetise specific **Key Performance Indicators**

Key beneficial impacts that can be delivered by C-ITS Services can be measured using known KPI - and the means of monetising them is established. These will be central to the business case and estimating the return on investment.

Importantly they will be key to post go live evaluation of the C-ITS service. Evaluation of the service will be important to confirm the original business case and justify further expansion of the C-ITS service. Further details are presented in chapter 4.7.

The monetary size of the beneficial impacts will depend on the use cases and services deployed.

Whatever use case used, the key impacts and benefits can be grouped as follows. Each have KPI's that can be measured and monetised.

- Road Safety – reduction in number and seriousness of accidents and fatalities
- Traffic Efficiency – Reduction in congestion, Vehicle Hours Lost, improved flow
- Environmental – CO2, CO, NOx, VOC, PM reductions
- Fuel Efficiency – Reduction in fuel consumption

Other beneficial impacts which will be apparent are:

- Improvement in quality and availability of real time traffic data
- Improved asset monitoring
- Increased comfort for drivers
- Improvement traffic regulation compliance.
- More reliable journey times and shorter journey times
- Potential reduction in roadside infrastructure (longer term)
- Improved safety for vulnerable road users and pedestrians
- Emergency vehicle prioritization

Estimate **costs** for the solutions

Fixed Costs

A business case will need an estimate of the fixed costs for the service. These will be the costs for implementing the C-ITS service. Fixed costs will be influenced by the type of use case services to be deployed, the overarching system architecture and the nature of the communications infrastructure. The latter could be either a 'privately owned' ITS-G5, commercial mobile or a combination (Hybrid). The costs can be considered under the following broad headings:

- Cost of implementing the communications services
- Highway infrastructure and roadside located communications infrastructure
- Back office systems and software including data services and accommodation
- Systems integration with existing hard and soft traffic management infrastructure

- Traffic control systems
- Planning, design and management
- (potentially in vehicle devices or on-board units (OBU))

Ongoing Costs

These costs are associated with the operating and maintaining the systems once commissioned. Again, they will be determined by the system architecture and the types of organisations who have provided the sub systems and services. These can be considered under the following headings:

- System operation, data acquisition, monitoring and control
- Costs associated with maintaining or providing the communications services
- Ongoing licenses for software and upgrades
- Hardware upgrade
- Security management
- Accommodation and utilities
- Management

Incorporate benefits **outside the confines** of the project

Monetising some beneficial impacts may in certain cases be challenging and identifying a realistic KPI may not be possible. For instance, the benefits arising from establishing a core system which might in the future contribute to accelerating wider deployment of C-ITS, or establishing connectivity with other systems or organisations who might receive a benefit but not necessarily attract significant or any cost.

Given that C-ITS services are in their infancy, and governments and industry are keen to see their availability widening in time to the extent they become ubiquitous, it might be appropriate to incorporate these benefits which may be viewed as sitting outside the immediate confines of the project.

These could for instance include, creation of a new industry and supply chain and further, costs which will have a ‘seed corn’ effect to encourage others to develop and widen deployment of C-ITS services in the future.

In these circumstances public sector funding will inevitably be required to deliver these wider benefits. The NordicWay2 evaluation report concluded, following wide consultation with industry and real-life experience, that if a wide and large-scale roll-out is to be achieved then it is inevitable that public involvement and intervention will be required.

The role the project plays in these wider contextual considerations will need to be determined. They could be at regional, national or European levels and, as appropriate a value placed on them so these wider benefits can contribute to the overall business case for implementation.

References:

NordicWay 2 Final Report Activity 8 – Finnish Pilot

NordicWay 2 Evaluation Report

CBA pattern should be recognised by all stakeholders

The specific form of the technical, economic and business case is not described here but it will need to follow a pattern that is recognised within the lead organisation for the project and the key stakeholder group. Whatever process is followed, the cost basis and areas where benefits will be derived are, at present, largely understood, although the size of these may not be immediately apparent (see chapter 2).

They will be very specific to the size of the project, extent of the services (and use cases) and its geographical location. For instance, benefits are known to be greater in highly trafficked areas rather than in largely rural situations at least in the early days of service provision. So, a more positive CBA is likely to be achieved on congested inter-urban and sub-urban routes rather than in less trafficked areas

The costs and economic benefits associated with provision of C-ITS services have been investigated during recent pilot projects and by bodies established by the EU and by Member States in recognition that C-ITS Services will have growing benefits to society. Reports from these organisations should be used and combined with the specifics arising in each Member State and the circumstances of the proposed project to formulate the business case.

Results from similar exercises undertaken to date have indicated that the benefits outweigh the costs.

Given that the business case is credible and justifiable, an informed decision can be made to enter Stage 2, to commence detailed planning and design for the project.

References:

NordicWay 2 Final Report Activity 8 – Finnish Pilot

NordicWay 2 Evaluation Report

4.7. Pre and Post Go-Live Evaluation – A Methodology

As described in chapter 4.6, monetised KPI will be a key input to the business case. Further, there will be a need for ongoing evaluation of the service post go-live to confirm the original business case and justify further investment and expansion of the services. A methodology therefore needs to be defined and it should use the same KPI, parameters and processes used to formulate the original business case. Establishing the evaluation process therefore needs to be done at an early stage preferably during the preliminary stages, ideally in conjunction with the business case, but certainly no later than stage 2.

The following figure illustrates the data flow within an evaluation process:

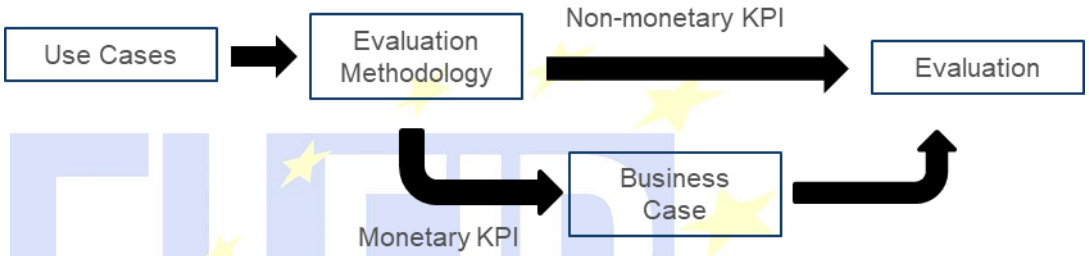


Figure 7: Overview about Evaluation

Typically, the evaluation distinguishes three areas:

- Impact Assessment
- User Acceptance
- Functional Evaluation

Within the impact assessment, the expected impacts of a system are measured and evaluated. The business case described in detail in chapter 4.6 will have monetised specific values defined within the impact assessment and compared them to the expected costs. With a post implementation comparison of expectations to results, the success rate of a system can be measured.

User Acceptance has a strong influence on some impacts and hence must be considered. If some users do not use a C-ITS service, the impacts related to the service will be reduced accordingly. Hence, it makes sense to consider this topic in detail.

Finally, a functional evaluation of the technical operation of the service, typically measuring availability of a service over time or the response time between system parts will highlight the actual quality of the service. This data will be useful to measure performance of any contractual agreements with organisations providing the elements of the service.

The following steps are typically taken to elaborate an evaluation methodology.

Definition of the **Expected Effects** and research questions

The use cases defined are selected to deliver the intended benefits to be generated by C-ITS which will in turn support transport policy aims and objectives.

As preparation for the evaluation, the benefits of each use case, be they monetarily relevant in the frame of a business case or scientifically helpful in the frame of impact and acceptance analyses, need to be defined in detail.

In typical C-ITS use cases, the benefits revolve around some or all of the following topics as described in chapters 2 and 4.6 as part of the business case process. It might also venture beyond them:

- Road Safety – reduction in number and seriousness of accidents and fatalities
- Traffic Efficiency – Reduction in congestion, Vehicle Hours Lost, improved flow
- Environmental – CO2, CO, NOx, VOC, PM reductions
- Fuel Efficiency – Reduction in fuel consumption

Other benefits which will be apparent are:

- Improvement in quality and availability of real time traffic data
- Improved asset monitoring
- Increased comfort for drivers
- Improvement traffic regulation compliance
- More reliable journey times and shorter journey times
- Potential reduction in roadside infrastructure (longer term)
- Improved safety for vulnerable road users and pedestrians
- Emergency vehicle prioritization

If required, also negative effects might have to be considered if they are linked to a given use case. For example, these might be longer waiting times (on average) for cars at an intersection where public transport or emergency vehicles enjoy priority.

For each of the aspects to be considered, research questions must be identified and documented in detail.

References:

ARCADE: Guidelines and Evaluation Methodologies (FESTA Handbook, Automated Driving Testing and Evaluation Materials Toolkit a.o.)

C-Roads Evaluation and Assessment Plan

Define **Key Performance Indicators** of the expected effects

Based on research questions, measurable units (Key Performance Indicators or KPI) are defined: -the KPI. They should include and be the same as those used in the business case formulated during the preliminary stage.

The process of why specific values are chosen as KPI and the expected changes, due to the service implementation, needs to be documented in detail.

The methodology also needs to define, how baseline data and evaluation data are collected prior and post implementation. This might influence the technical solution so pertinent data can be obtained.

As an example, one KPI concerning improved traffic efficiency might be travel time. So, the KPI would be measured on certain road stretches before and after implementation and then compared. The data sources might not be the same prior and after the implementation, but special care must be given to comparability. For example, Floating Car Data (FCD) are sourced from FCD data providers for the baseline value and from the implemented C-ITS services for the post implementation. If the latter would be individual vehicle data, they would have to be aggregated to provide a comparable value since FCD data providers usually provide aggregated data as well.

References:

ARCADE: Guidelines and Evaluation Methodologies (FESTA Handbook, Automated Driving Testing and Evaluation Materials Toolkit a.o.)

C-Roads Evaluation and Assessment Plan

Define **thresholds** for Key Performance Indicators

For each Key Performance Indicator (KPI), the value expected to be reached post implementation needs to be defined and also used to inform the business case. The process and reasoning why this is expected needs to be documented in detail, especially in the case of educated guesses - if no suitable basis exists (e.g. the use case was not implemented as yet in a similar environment).

Continuing the example of the KPI on travel time, a percentage reduction might be expected due to a specific use case and related service.

References:

ARCADE: Guidelines and Evaluation Methodologies (FESTA Handbook, Automated Driving Testing and Evaluation Materials Toolkit a.o.)

C-Roads Evaluation and Assessment Plan

Establish **Baseline Data** for Key Performance Indicators

For each Key Performance Indicator (KPI), baseline data must be collected prior to implementation.

With technical KPI related to impact assessment, a baseline usually needs to be established for later reference. Usually this can be achieved by measurement of the KPI parameters.

Concerning KPI related to user acceptance, baselines might be required as well for instance by holding surveys among the future users of a service prior to implementation.

KPI related to the functional evaluation don't usually require a baseline as they form requirements towards a future system. This might for instance relate to maximum system downtime which is not compared to any baseline.

References:

ARCADE: Guidelines and Evaluation Methodologies (FESTA Handbook, Automated Driving Testing and Evaluation Materials Toolkit a.o.)

C-Roads Evaluation and Assessment Plan

Evaluation **must accompany** the whole implementation process

The evaluation must accompany the whole implementation process from the beginning preliminary stage through to go live and operation. However, the specific steps might partially be executed during later phases while considering binding ancillary conditions.

One example might be, that baseline KPI for system performance (e.g. availability) are required for incorporation into system specifications and tendering. As another example, only monetarily relevant KPI might be defined prior to the business plan based go/no go decision detailed in the previous chapter. In such case, the elaboration of the detailed methodology can be executed after the go/no go decision. This might

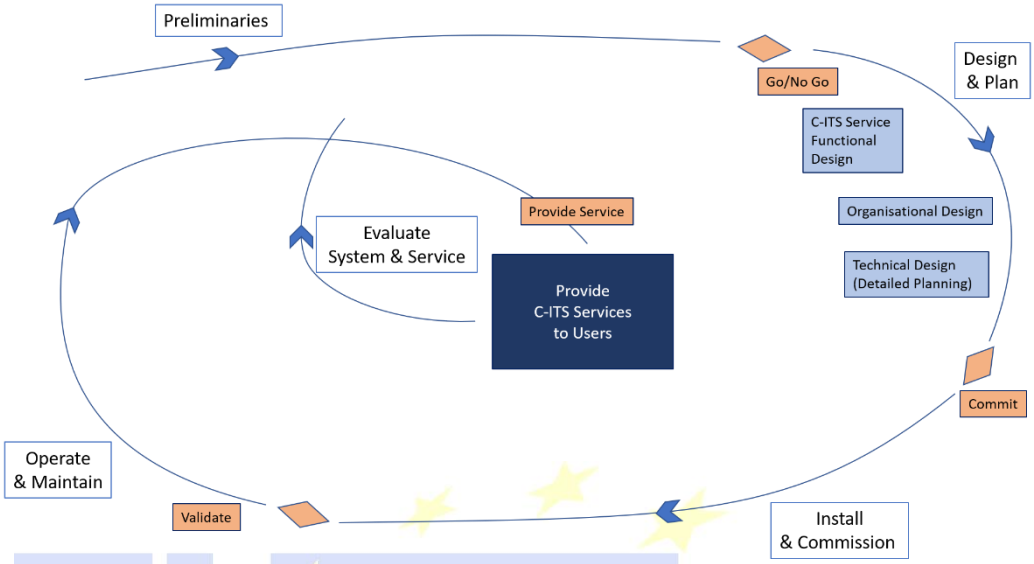
be the case if national frameworks for the assessment of the economical feasibility of a system (such as the German "RE-Entwurf") exist which prescribe specific KPI.

Generally speaking, a transparent documentation of the methodology and the reasoning for estimated benefits is key to a transparent and ultimately helpful evaluation.

References:

- Safety assessment methodology (Kulmala, 2010):
- NordicWay 2: Evaluation Report, example of safety impact evaluation in project (e.g. page 25; impacts)
- C-Mobile (2018): Ex-ante evaluation report

5. Plan and Design C-ITS Services



5.1. Functional Design of the C-ITS Service

- Decide how the Use Cases are deployed – **long-range or short-range**?
- Identify **synergies** of Use Cases
- Determine the striven **quality criteria** for the Use Cases
- Document the **overall architecture**
- Decide which **public key infrastructure** will be used
- Consider legal basis for processing **personal data**

Decide how the Use Cases are deployed – **long-range or short-range**?

In the Preliminaries Phase, the use cases to be deployed were selected. If possible, it should be specified how the use cases will be implemented. For instance, it should be clear for each use case whether it is to be implemented for short-range communication or long-range communication.

Moreover, this step can be used to check if the same messages of the use cases deployed can be sent on several ways without too much effort, e.g. warning messages broadcast of a roadside unit can also be published via long-range communication.

Identify **synergies** of Use Cases

For many use cases, systems and processes can be used synergistically.

Simple examples could be that a backend system can easily provide different types of messages via the same interface to an interchange node or end-user applications or that one roadside unit can broadcast various messages for different use cases.

A more complex connection of use cases would be to use PVD received from a mobile roadside unit at short-term road works warning to refine the traffic model within the traffic management centre in order to improve the dynamic speed limit information.

Define the striven **quality criteria** for the Use Cases

For further functional, organisational and technical design, the expectations to the C-ITS service and use case concerning the quality should be clear. Quality of a C-ITS service can have various facets and should be clearly defined. The quality criteria can also differ for the use cases, e.g. the location accuracy for In-Vehicle Signage is much easier to be determined than for hazardous locations which can occur spontaneously.

References:

EU EIP Sub-Activity 4.1 (2021): C-ITS Quality Package (2021)

Document the **overall architecture**

An overview of the interplay between the different functions will be helpful in the procurement phase for the bidders to understand the part of the C-ITS service to which they contribute. Comprehension of the functional intentions will also enhance the decisions for organisational and technical specifications.

Decide which **public key infrastructure** will be used

In order to build up the C-ITS Trust Domain, the EU CCMS has been established (see also info box on page 22). The C-ITS units to be deployed must enroll with a public key infrastructure (PKI) and obtain certificates from it on a regular basis. It has to be decided whether to operate an own PKI registered with the ECTL or whether an existing PKI can be used.

The Commission Expert Group on C-ITS Security (E01941) has defined three levels of environments for the ECTL. Level 0 for testing purposes, Level 1 for first C-ITS implementations and Level 2 for long-term operation of C-ITS services with full audit mechanisms required.

References:

EC (2021): C-ITS Point of Contact

C-Roads (2019): Draft Report on European Security Mechanism

Consider legal basis for processing **personal data**

In case of planned processing of vehicle data, the legal basis for processing personal data should be considered from the beginning on. If data sent by the vehicles on the roads is intended to be received, processed and used, the legal basis can affect the functional possibilities. As (generally spoken) user consent or explicit legal allowance are necessary, the processing depth can be restricted.

References:

Article 29 Data Protection Working Party (2017): Opinion 03/2017 on Processing personal data in the context of C-ITS

European ITS Platform

5.2. Organisational Design

- Analyse the state-of-play of legal circumstances of the deployment framework
- Draft the intended **service chain**
- **Involve** other C-ITS actors
- Identify **interfaces** to other C-ITS actors
- Draft **internal processes** adapted to the day-to-day business of people active in the field

Analyse the state-of-play of legal circumstances of the deployment framework

Before designing interactions of stakeholders and their systems, the current legal state-of-play should be analysed thoroughly. The boundary conditions are set through the security framework, compliance assessment framework, spectrum allocation, governance framework, standards and privacy framework. These elements have each been described with a fact sheet in the Report on legal structures for C-ITS Operation. Besides the generally valid descriptions, national or regional circumstances should be elaborated.

References:

C-Roads (2017): Report on legal structures for C-ITS Operation

European ITS Platform

Draft the intended **service chain**

Since many actors contribute to a C-ITS service, it should be defined clearly who will contribute which part of the service chain. With a template like the one used in the Report on legal structures for C-ITS Operation, missing parts in the service chain can be avoided and interfaces between different actors can be made visible.

References:

C-Roads (2017): Report on legal structures for C-ITS Operation

Involve other C-ITS actors

Identify relevant C-ITS actors which are already active. You can learn from their experience and involve them into decisions, especially if they are part of the service chain.

Identify **interfaces** to other C-ITS actors

For a smooth information flow, interfaces to other C-ITS actors should be identified. Interfaces are not necessarily only technical specifications. Also agreements, duties, expectations (who will receive what information at what time by whom? – including Service Level Agreements) are examples for organisational interfaces.

Draft **internal processes** adapted to the day-to-day business of people active in the field

Besides the external processes where interfaces to other C-ITS actors need to be clear, the internal processes within your organisation also need to be specified adequately. Therefore, it is always useful to involve the employees who will be in charge of using the new equipment and performing the newly defined processes and who will have to integrate that into their existing tasks.

European ITS Platform

5.3. Technical Design (Detailed Planning and Design)

- Make use of the latest **System Profiles** of C-Roads
- Identify the **quantity** and **locations** of roadside units (in case of short-range communication
- Define **communication** between roadside units and back office infrastructure (in case of short-range communication)

Make use of the latest **System Profiles** of C-Roads

When implementing a C-ITS service on the infrastructure side, the most important thing is that the vehicles or receiving systems are able to process the information in such a way that the road user can benefit from it. Therefore, it is important to know which standard versions and specifications are currently in use. Within the C-Roads platform, all necessary specifications on the infrastructure side are harmonized and regularly published with new releases.

References:

C-Roads (2021): Harmonised C-ITS Specifications

Identify the **quantity** and **locations** of roadside units (in case of short-range communication)

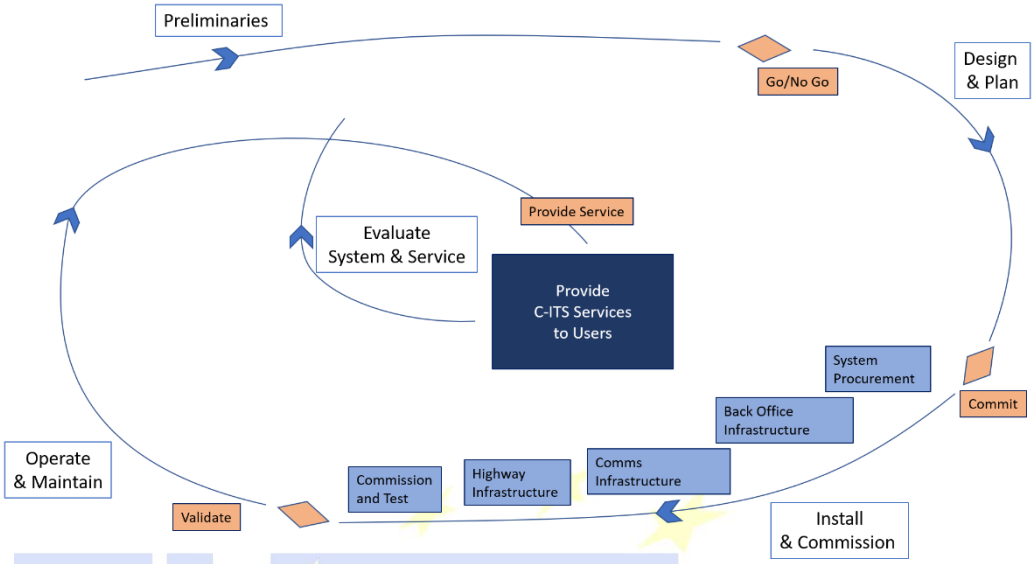
If the C-ITS service is intended to be delivered via short-range communication, roadside units have to be installed and operated. The best locations for fixed or mobile roadside units should be evaluated wisely. The line of sight should be as clear as possible, but also power supply and internet connection (wired or mobile) have to be guaranteed. These decisions can also impact the quantity of required roadside units.

Define **communication** between roadside units and back office infrastructure (in case of short-range communication)

Roadside units need an internet connection, at least to draw certificates (see also C-ITS Trust Domain in section 1.3). A mobile internet connection often seems to be the quick-win solution if no fast internet connection is available. In some cases, the opportunity can be used to

install a wired connection also for additional purposes, e.g. for establishing a safe and efficient connection between traffic lights and traffic management centre.

6. Install and Commission C-ITS Services



6.1. System Procurement

- Identify appropriate **partitions of procurement** packages
- Back-Office Infrastructure: **Integrate** the new system into the existing infrastructure
- Roadside Infrastructure: Consider **split** of procured equipment to different suppliers Identify **interfaces** to other C-ITS actors

Identify appropriate **partitions of procurement** packages

Within the service chain, there are usually various tasks for the road operator. Work at the existing systems and installation of new equipment and applications should go hand in hand.

Purchasing as much as possible from one provider can seem to be a quick solution which keeps the procurement effort low. To find the most competent and economic providers, partitioning the procurement packages may be reasonable.

Back-Office Infrastructure: **Integrate** the new system into the existing infrastructure

The back-office infrastructure of a road operator has often developed incrementally from time to time. Deep integration of new C-ITS services to the existing infrastructure is therefore not straightforward and may vary for every back-office infrastructure. Since many use cases like warnings to the user rely on low latencies, the integration should be specified with the overall backend system in mind.

Roadside Infrastructure: Consider **split** of procured equipment to different suppliers

Roadside equipment is needed in large quantities for short-range communication. To avoid lock-in effects and to keep competition, the procured equipment may be split so that equipment of different suppliers is used.

6.2. Commission and Test

- Define test method, test environment, test process, test cases
- Unit test to integration test to system test; partial test to overall test
- Perform compatibility test, performance test, conformance test, security test
- Cross-border testing of harmonization and interoperability

Define test method, test environment, test process, test cases

To ensure a proper functionality of the commissioned C-ITS service, test method, test environment, test process and test cases should be defined beforehand.

Unit test to integration test to system test; partial test to overall test

Tests after the implementation should be conducted systematically. The principle “from small to big” can be used on a physical level (first test single units, then the integration of single units, then the larger system) or on a functional level (first test single functions and at the end the overall system).

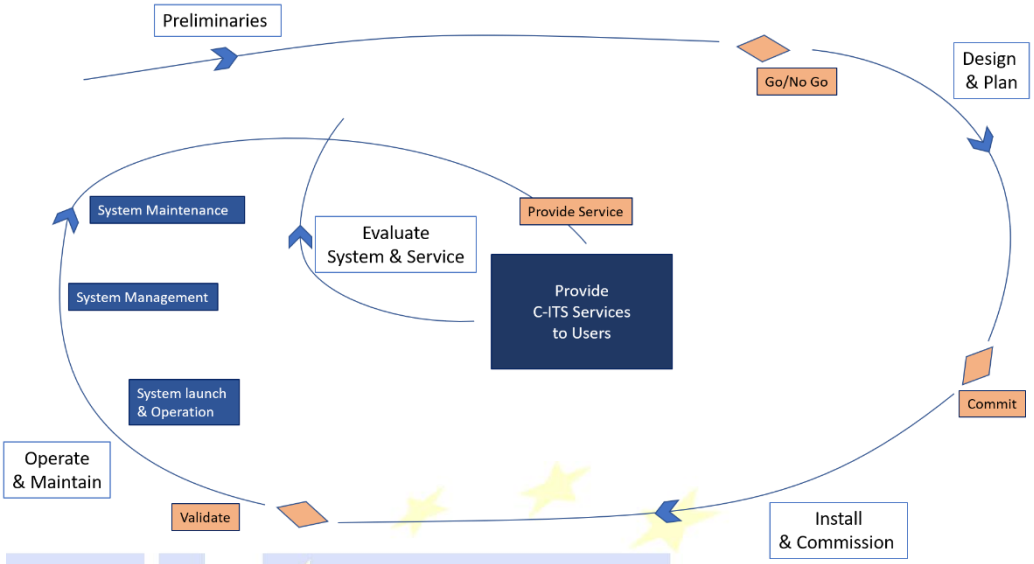
Perform compatibility test, performance test, conformance test, security test

Tests should cover different aspects such as compatibility with other systems, performance, conformance and security tests.

Cross-border testing of harmonization and interoperability

Testing with a small group of well-known participants potentially does not cover all possible cases. As interoperability with a variety of different users is key to C-ITS services, cross-border testing may be the best solution to cover as many different cases as possible and to discover issues which would not occur in a small and well-known testing group.

7. Operate and Maintain C-ITS services



- Establish measures and processes to ensure **compliance** with all applicable regulatory frameworks
- Manage all **change** processes from initial state to target state, including all aspects of implementation
- Establish processes to deal with **incidents** and problems in a way that they get **resolved** and issues are addressed at the right level
- Ensure that ITS services and infrastructure are able to deliver the agreed **capacity and performance** targets
- Ensure the correct **assignment** of **configuration** items and their relationship in the operating environment
- **Commissioning** and **decommissioning** procedures should be established
- Manage **supplier** and **contractor** relationships
- Take care to closely monitor **incidences and disturbances** in the system and establish a response system
- Identify and manage known **disturbances** or **problems**
- Carefully administer who has **access** and establish a sound **security management**
- Implement **changes** from a **central instance**
- **Monitoring**

The operation of C-ITS services comprises all activities related to the day-to-day functioning of the C-ITS infrastructure as well as requirements needed for ensuring a high level of service availability for the users. The primary goal is to keep ongoing operations secure and with minimal disruptions. Strategic subjects such as overarching guidelines for operations, the compliance of the cooperative services, and also the further development of both existing and new services should additionally be taken into account when dealing with the operation of C-ITS services. Moreover, thorough coordination with other roles / players is required to ensure availability for the user throughout the entire process chain of each service (end-to-end availability).

In Germany, in the scope of the C-ITS Corridor project, the ITIL® V3 process model is used to define the processes necessary for running operations. The IT Infrastructure Library (ITIL®) is a collection of best practices of different publications showing how to implement IT Service Management (ITSM) and by now it is an international de-facto standard for IT-business processes.

The following section presents the most essential processes necessary for operating and maintaining C-ITS Services.

Establish measures and processes to ensure **compliance** with all applicable regulatory frameworks

Compliance management ensures that IT services, processes and systems comply with corporate policies, legal regulations and technical standards. This includes tasks such as deriving operational requirements from legal regulations, developing the underlying concepts and instructions for operation as well as the coordination with other functions, amongst others.

Manage all **change** processes from initial state to target state, including all aspects of implementation

All changes to the cooperative systems and its components (configuration items) should be evaluated, authorized and documented in order to minimize disruptive effects on ongoing operations. When a change has an impact on components that are outside a function, they should be compiled as RfCs and managed from a central position, in order to evaluate the RfCs with regard to their impact on other components. Based on this, overarching coordination and authorization of the changes can be initiated.

Establish processes to deal with **incidents** and problems in a way that they get **resolved** and issues are addressed at the right level

Escalation management outlines procedures that result in certain decisions being shifted to another level, when in conflict situations no consensus or resolution is possible.

Hierarchical escalation defines processes for decisions being shifted to respective superiors or committees in situations when no mutual consensus is possible at a lower decision-making level.

Functional escalation, in turn, specifies procedures for handing over the processing of topics to expert groups, when the solution to conflicts simply cannot be found.

Ensure that C-ITS services and infrastructure are able to deliver the agreed **capacity, performance and quality** targets

In order for business requirements to be met, required resources regarding hardware, software and personnel, necessary for operating all C-ITS components should be carefully planned. This can be achieved through creating capacity plans. In addition to resource planning and managing capacity plans, initiating new acquisitions should be included in the capacity management. Through the ongoing maintenance of capacity plans, forecasts for future demands can be derived, from which in turn plans also for future resource requirements can be developed.

Ensure the correct assignment of **configuration** items and their relationship in the operating environment

All data relating to hardware and software components of the cooperative systems should be recorded, managed and actively documented. For this, creating a logical model of the cooperative system is suggested. This model shows how the various components (configuration items) interact to provide the services.

On an operational level this includes maintaining technical documentations (e.g., manuals and specifications), updating the configuration data including documentation of changes as well archiving the data.

Commissioning and **decommissioning** procedures should be established

A proper commissioning process should be established to ensure that both new C-ITS stations as well as changes to existing C-ITS stations can be transferred to active operation via a controlled procedure and according to an appointed schedule. This process should therefore include takeover into operation, final inspection/approval of the C-ITS stations and registration of the PKI. This process should also include possibilities for up-to-date documentation and entries in a configuration database.

Likewise, a decommissioning process should be established in order to enable that a C-ITS station can be taken out of service, either in part or in its entirety, without disrupting the operation of dependent components. In general, components that are no longer required or serve a purpose should be decommissioned. This process should include deregistration of the PKI as well the proper disposal of the components.

Manage **supplier** and **contractor** relationships

Relations with suppliers who support the operation of the services should be closely managed. Generally, it should be ensured that all suppliers fulfil their contractual obligations. This includes matters such as contracts, invoices and tenders.

Take care to closely monitor **incidences and disturbances** in the system and establish a response system.

A system should be established to handle disturbances and incoming reports of incidences during operation, in order to restore the uninterrupted function of the cooperative systems as quickly as possible. This should include:

- local monitoring of incidences and collection of incidence notifications
- reporting malfunctions to R-ITS-S manufacturers or to the service provider(s) responsible for their maintenance
- establishing designated contact personnel (e.g. 24/7 / during office hours / on-call service etc.)
- carrying out repairs within predefined response times (or having this arranged)
- quality control and review of warranty claims

Identify and manage known **disturbances** or **problems**.

Through analysing and documenting arising disturbances or problems, causes of severe malfunctions or multiple problems with the same symptoms can be identified and long-term solution strategies can be developed. Moreover, workarounds for known malfunctions that cannot be solved immediately can be integrated into the incidence response system.

On an operational level, this translates to analysing systematic errors and identifying their causes, formulating long-term solutions as well as the creation of RfCs to eliminate the errors.

Carefully administer who has **access** and establish a sound **security management**

Security management ensures that all goods, information, data and services of a company are protected at all times with regard to their confidentiality, integrity and availability and that central requirement are implemented and complied with.

Security-critical events and information should be generated in the form of messages and alarms. These are evaluated by security management and instructions for action are issued. Furthermore, solution scenarios for possible threats are proactively developed here.

Access management grants authorized users the right to use a service and at the same time prevents access for unauthorized users. This essentially carries out the requirements that have been defined in security management.

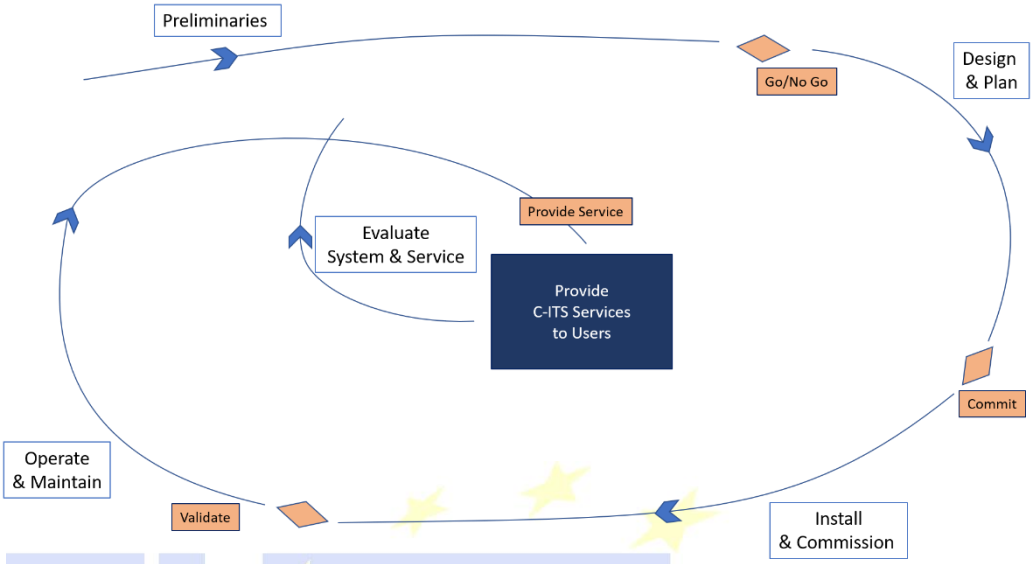
Implement **changes** from a central instance

Release management, as a central instance, should be responsible for implementing changes to the cooperative systems to ensure that they are carried out effectively, securely, and traceably. Tasks include planning, monitoring and executing rollouts for changes authorized by through the change management.

Monitoring

In general, all operational components and services should be continuously controlled via a monitoring system. It should be possible to filter and categorize by events in order to initiate suitable actions if necessary. Monitoring includes the registration and deregistration of R-ITS-S in a monitoring system, continuous (automated) monitoring of hardware and software of the R-ITS-S components as well as the collection and evaluation of the monitoring data (ex-post)

8. Evaluate C-ITS System and Services



The evaluation activities stretch over the whole project period with the methodology definition and baseline collection prior to the implementation and a sometimes-constant data collection during the operation of a system, e.g. in case of functional assessment related KPI.

The evaluation steps described in this chapter comprise the measurement of the level of fulfilment of expectations and the elaborations of recommendations for improvements.

Assessment of effects

The assessment process has to be defined in the evaluation methodology and compares KPI collected after implementation to either base values or requirements based on the expected impacts.

- Impact Assessment
- User Acceptance
- Functional Evaluation

In practise, as the implementation does not happen in a laboratory environment, KPI might be affected by aspects not considered in the evaluation methodology. For example, the reduction of travel time on a link caused by a C- ITS service might be distorted by a general rise in traffic volume which offsets some of the positive effect. Within the evaluation, such

effects must be considered when KPI collected post implementation and the methodology adapted accordingly, if necessary.

References:

- ARCADE: Guidelines and Evaluation Methodologies (FESTA Handbook, Automated Driving Testing and Evaluation Materials Toolkit a.o.)
- C-Roads (2019): Evaluation and Assessment Plan

Derive **proposals for improvements**

Based on the evaluation results, the potential for improvement needs to be identified.

The interference between the impact of a system and its user acceptance level and the service quality indicated by the functional evaluation shall be considered. Improvements to the impacts might lead via the latter two areas.

References:

- ARCADE: Guidelines and Evaluation Methodologies (FESTA Handbook, Automated Driving Testing and Evaluation Materials Toolkit a.o.)
- C-Roads (2019): Evaluation and Assessment Plan

It should be noted that evaluation issues should be prominently included in the early phases of work plans of any C-ITS related project, in order to detail the evaluation and assessment plan (taking advantage of the FESTA V concept). After this first phase, evaluation and assessment is a task which is on watch while pilots are implemented, data is collected etc. Most of the work on evaluation and assessment is typically compressed in the last phase of projects and typically faces significant time constraints. When building projects, sufficient time should be allocated to carefully evaluate KPIs and impacts or when feasible to decouple the overall project lifetime from the evaluation timeline (to allow for postprocessing of the KPIs and impact).

PART III : C-ITS Landscape

This part of the document gives an overview of the various projects and stakeholders in the C-ITS landscape.

The Who is Who in chapter 9 describes important organisations, associations and other institutions who have played a major role in the evolution of C-ITS service deployment in the past and in the presence.

Chapter 10 clusters the activities of these organisations to the categories *Harmonization*, *Horizontal*, *Legal* and *Assessment & Roadmap*.

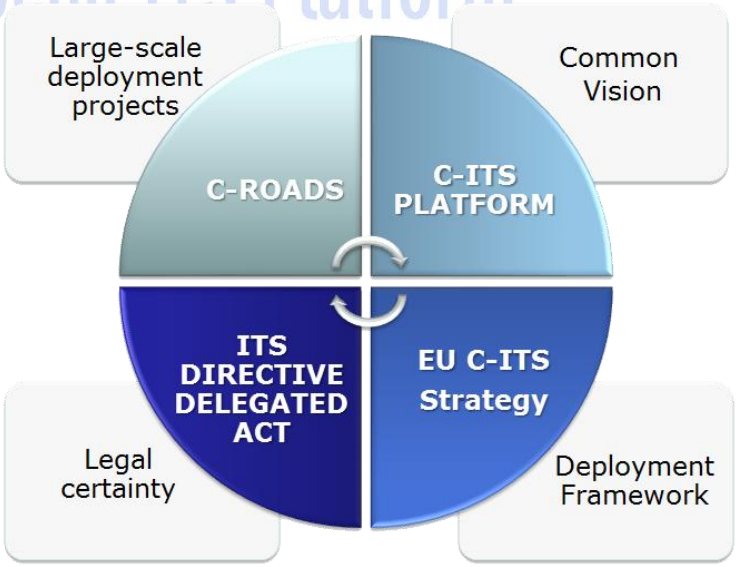
More overviews of relevant organisations, projects and literature in the C-ITS domain are added in the annexes.

9. Who is who in C-ITS

This section describes the main European initiatives and actors in the field of C-ITS.

9.1. European Commission

The European Commission has set up a European Framework for C-ITS Deployment, visualised in the C-ITS Wheel shown below. This C-ITS Wheel shows the policy tools available to the European Commission. In the C-ITS Platform a common vision towards Pan-European Deployment of Cooperative, Connected and Automated Vehicles has been developed. Then there is the European Strategy on Cooperative Intelligent Transport Systems (C-ITS), which was adopted by the European Commission on the 30th of November 2016, a milestone initiative towards cooperative, connected and automated mobility (CCAM). The objective of the C-ITS Strategy is to facilitate the convergence of investments and regulatory frameworks across the EU, in order to see deployment of mature C-ITS services in 2019 and beyond. This includes the adoption of the appropriate legal framework at EU level to ensure legal certainty for public and private investors, the availability of EU funding for projects, the continuation of the C-ITS Platform process as well as international cooperation with other main regions of the world on all aspects related to cooperative, connected and automated vehicles. It also involved continuous coordination, in a learning-by-doing approach, with the C-Roads platform, which gathers real-life deployment activities in Member States. Lastly, the ITS Directive (2010/40/EU) provides the legal framework to support the coordinated and coherent deployment and use of Intelligent Transport Systems (ITS) within the European Union, in particular across borders.



Implementation Guidance for C-ITS services with infrastructure involvement

On 13 March 2019, the Commission adopted a delegated regulation on specifications for the provision of C-ITS, supported by an impact assessment. The delegated regulation did not enter into force following an objection by the Council of the European Union.

More information on the European Commission:

- EC (2016): C-ITS Strategy
- Press release: "Commission presents a Strategy towards cooperative, connected and automated mobility" (2016)
- EC (2021): Cooperative, Connected and Automated Mobility

9.2. CCAM Single Platform - Cooperative, connected and automated mobility

On the 3rd of June 2019, the European Commission presented its EU-wide platform - The Cooperative, Connected, Automated and Autonomous Mobility (CCAM) Single Platform consisting of an informal group of both private and public stakeholders. The CCAM Single Platform is a joint directive of Directorates-General for Mobility and Transport (DG MOVE), Communications Networks, Content and Technology (DG CNECT), Internal Market, Industry, Entrepreneurship and SMEs (DG GROW), Research and Innovation (DG RTD).

The aim of this platform is to advise and support the EC in the area of open road testing and making the link to pre-deployment activities. This is done through the coordination of CCAM research, piloting, testing and deployment activities, in order to increase their efficiency and effectiveness as well as integrate existing fora. The group has also addressed (final meeting: 24th of September 2021) any issues related to data access and exchange, digital and road transport infrastructure, communication technology, cybersecurity and road safety.

Alongside the plenary meetings, another aspect of the platform managed by the EC are a series of working groups, specialised on various topics:

WG1 Develop an EU agenda for testing

WG2 Coordination and cooperation of R&I

WG3 Physical and digital road infrastructure

WG4 Road safety

WG5 Cybersecurity and access to in-vehicle data linked to CCAM.

WG6 Connectivity and digital infrastructure for CCAM

More information about the CCAM Single Platform:

- EC (2021): Final Report of the CCAM Platform
- EC (2021): Expert group on CCAM

9.3. Amsterdam Group

The Amsterdam Group is a voluntary cooperation platform of the leading European ITS stakeholders in the world of mobility. It includes key stakeholders who have the means to jointly develop and deploy cooperative ITS in Europe. As an organisation they have driven the progress towards C-ITS Deployment for several years, before the European Commission has stepped into this field to create a deployment framework shared by all actors and stakeholders.

The Amsterdam Group is active to facilitate information exchange, discussion and creation of solutions between the involved stakeholders in the context of C-ITS.

The role of the Amsterdam Group is to:

- Facilitate dialogue between actors, e.g. on corridors results and needs
- Provide integrated communication interface towards the individual members of the Amsterdam group
- Facilitate exchange of experience between corridors, front runners, etcetera.
- Communicate with EC and other bodies (e.g. ETSI/CEN)
- Provide functional specifications for C-ITS services as input for standardization
- Taking away barriers for deployment

The Amsterdam Group's major stakeholders are working closely together towards concrete targets and following clear road maps. The Amsterdam Group's roadmap prioritises 'Day One Applications' to be implemented in the first phase in major European regions starting from 2015. Following a stepwise approach, the members of the Amsterdam Group will facilitate the roll out of mature and realistic market-oriented applications with increasingly wider geographical and market scope.

Most of the roles in facilitating the information exchange, learning effects and encouraging close collaboration within a network of pilots and deployment initiatives has been taken on board by the C-Roads Platform (incl. intense exchange with custodians of communication profiles in the automotive sector, in order to arrive at a cross-sector harmonisation of profiles. These days, the Amsterdam Group is especially engaged in organising exchange on lessons learned and deployment plans with key actors on other continents, mostly alongside ITS World Congresses.

More information about the Amsterdam Group:

Geissler (2016): Presentation at the ETSI ITS Workshop

ITS International (2013): Amsterdam Group turn ITS theory into practice

9.4. C-Roads Platform

The C-Roads Platform is a joint initiative of European Member States and road operators for testing and implementing C-ITS services in light of cross-border harmonisation and

interoperability. Through the C-Roads Platform, authorities and road operators join together to harmonise the deployment activities of cooperative intelligent transport systems (C-ITS) across Europe. The goal is to achieve the deployment of interoperable cross-border C-ITS services for road users. The C-Roads Platform is an open platform, co-funded through Connecting Europe Facility (CEF).

The C-Roads Platform aims at making European roads safer for citizens, traffic more efficient and reducing harmful emissions from transport. The project is planned to run until the end of 2020. Currently 18 European States are participating as core members (in 2016 it started with 8 core members).

At the start of the C-Roads Platform, in October 2016, three Working Groups were established, with the option that further topics will be added if needed in order to achieve interoperable pilot deployments. The Working Groups contain the main aspects of work to reach the overall C-Roads objectives.

The following Working Groups and Task Forces were agreed:

1. Working Group Organisational Aspects
2. Working Group Technical Aspects
   - Task Force Security Aspects (TF1)
   - Task Force Service Harmonisation (TF2)
   - Task Force Infrastructure Communication (TF3)
   - Task Force Hybrid Communication (TF4) – added later
   - Task Force Cross-Testing and Validation (TF5) – added later
3. Working Group Evaluation and Assessment
4. Working Group Urban C-ITS Harmonisation – added later
5. Working Group Digital Transport Infrastructure (DTI) - added later

More information about the C-Roads Platform:

C-Roads Platform Website

C-Roads documentation

9.5. The European Data Task Force - DTF - and Data for Road Safety initiative - DFRS

On the 15th of February 2017, during the High-Level Meeting on Connected and Automated Driving, all European Transport Ministers, the European Commission and current industry partners agreed on the establishment of the Data Task Force. Its mission is to improve road

safety by maximizing the reach of safety-related traffic information powered by safety data generated by vehicles and infrastructure.

The Safety Related Traffic Information (SRTI) Ecosystem was created by the Data Task Force members for the exchange of data and information under the terms and conditions of the Multi Party Agreement and thus creating a trust domain for that exchange.

The Data Task Force was structured around 3 core principles:

1. Working together to make driving safer. Safer driving is a shared vision amongst government and industry stakeholders and is a key founding for this public-private partnership.
2. Safety without compromise. Vehicle data has the potential to save lives. By making safety data a priority and share data across brands and across borders, we can maximize the benefit it brings and enhance road safety.
3. A fair and trusted partnership. The Data Task Force is a trusted partnership of government and industry stakeholders that enables fair competition.

In their Final report from October 2020, the following are mentioned regarding the future of DTF: 'The Data Task Force has completed its primary task: accelerating the deployment of data sharing for SRTI (Safety Related for Traffic Information). In the light of the 'Programme Support Action on a Coordination Mechanism to Federate National Access Points and National Bodies' and the possible revision of the Delegated Regulation on the provision of Real Time Traffic Information, it is undesirable at this point in time to expand the scope to traffic- and mobility management as requested by the Transport Ministers at the High-Level Structural Dialogue in Frankfurt (September 2017).

On 3 December 2020 the Data for Road Safety initiative (DFRS), announced that it is aiming for the long-term deployment of a Safety-Related Traffic Information (SRTI) ecosystem which will warn drivers about dangerous driving conditions. A multi-party agreement (MPA) was signed in which automobile manufacturers, automotive suppliers, road traffic authorities, EU member states and location technology providers commit to the long-term exchange of safety data in order to make roads safer. The agreement, which has a duration of 5 years, defines the technical and organisational framework of how safety data from multiple brands and multiple countries can be made accessible and used within the SRTI eco-system in a fair and trustworthy manner. It also defines the roles and responsibilities along the SRTI value chain. The SRTI ecosystem is based on a reciprocity model – with safety data being offered in return for safety services.

More information on DTF and DFRS:

- Declaration of Amsterdam (2016): "Cooperation in the field of connected and automated driving"
- Video Data Task Force
- Data Task Force (2020): Final report & recommendations
- Data Task Force and Data for Road Safety website

9.6. 5G Automotive Association - 5GAA

Created in September 2016, the 5G Automotive Association (5GAA) is a global, cross-industry organisation of companies from the automotive, technology, and telecommunications industries (ICT), working together to develop end-to-end solutions for future mobility and transportation services. The mission of the association is to make transportation safer, greener and more enjoyable, by accelerating the development of C-ITS technologies.

5GAA has seven Working Groups (WG) that develop the frameworks, practical aspects, required standards, and business cases for 5G and the future application of connected mobility solutions. They are focusing on the following topics:

1. Use Cases and Technical Requirements (WG1)
2. System Architecture and Solution Development (WG2)
3. Evaluation, Testbeds, and Pilots (WG3)
4. Standards and Spectrum (WG4)
5. Business Models and Go-To-Market Strategies (WG5)
6. Regulatory and Public Affairs (WG6)
7. Security and Privacy (WG7)

More information about 5GAA:

5GAA website

9.7. The CAR 2 CAR Communication Consortium - C2C-CC

Started in 2002, the CAR 2 CAR Communication Consortium (C2C-CC) unites leading European and international vehicles manufacturers, equipment suppliers, engineering companies, road operators and research institutions. It focuses on research and development of C-ITS solutions facilitating to overcome road accidents (vision zero). The consortium further aims at supporting the highest safety level at improved traffic efficiency anywhere, anytime at the lowest cost to the end user and the environment.

The objective of the C2C-CC also extends to worldwide harmonisation and promotion of C-ITS as far as required enabling C-ITS to exploit its full potential. Therefore, the C2C-CC contributes to European and International standardisation and harmonisation activities for development of technical specifications, required for Cooperative Intelligent Transport System (C-ITS), including V2X (vehicle-to-everything) communication.

In 2019 the first mass market vehicles equipped with cooperative V2X (C-V2X) as standard entered the European market. By closely collaborating with the infrastructure industry, road authorities, road operators, cities and regions, in the Amsterdam Group and C-Roads across

Europe, the Consortium fosters the cooperative V2X (C-V2X) development and supports its deployment.

More information about C2C-CC:

C2C-CC website

9.8. C-ITS Deployment Group

C-ITS Deployment Group is an association of vehicle manufacturers, road infrastructure providers, authorities and federal states, as well as industry and ICT and research partners, which aims to increase road safety and decrease congestions on Europe's motor- and expressways by deploying C-ITS, a technology to enable communication between vehicles and digital road infrastructure. It brings together the most prominent automotive manufacturing companies and interest groups in the traffic and transportation sector.

Its main objectives are:

- Promote the implementation of C-ITS, supporting road safety and traffic flow improvement, contributing to a new era of cooperative and connected mobility in the deployment of C-ITS across Europe.
- Act as an interface between road operators, industry and research facilities, providing a platform for all supporters to discuss, improve and share information about C-ITS activities.
- Being a platform for deployment partners, by sharing knowledge and expertise

More information about C2C-CC:

C-ITS Deployment Group website

9.9. The sub-group on C-ITS of the Commission Expert Group on Intelligent Transport Systems

The sub-group on C-ITS of the Commission Expert Group on ITS has been setup in 2020 as a continuation of the Working Group Security (WG5) of the C-ITS Deployment Platform (see 9.2).

The group will support the European Commission in the implementation of the pilot on common EU-wide cybersecurity infrastructures and processes needed for secure and trustful communication between vehicles and infrastructure for road safety and traffic management related messages and to foster exchange of experience and good practice in the field of C-ITS.

The main tasks of this sub-groups are as follows:

- The EU CCMS (C-ITS security credential management system) is one of the key pillars of the operation of C-ITS, and this group should be instrumental to support its implementation, as was also foreseen in the delegated regulation.
- While a formal CPA (Certificate Policy Authority) is not yet established, this sub-group de facto implements the tasks of the CPA in the currently best available way.

The members of this sub-group are security experts from the industry, road operators and Member States that are working together on the operationalisation of C-ITS in the European Union.

More information about the sub-group C-ITS:

- Commission Expert Group on C-ITS
- Certificate Policy for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS)
- Security Policy & Governance Framework for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS)

9.10. Conference of European Directors of Roads Connected Automated Driving Working Group - CEDR's CAD WG

CEDR is an organisation of European national road administrations that promotes excellence in the management of roads. CEDR is of the opinion that digitalisation will influence all aspects of transport. This includes the aspects of traffic operations such as connected vehicles, integrated network management (including intermodality) as well as the planning and management of infrastructure with tools such as Building Information Modelling (BIM) and the Internet of Things. Connected and Automated Driving (CAD) is part of this development. The continuing acceleration of CAD by vehicle manufacturers is going to have a significant impact on road operation, traffic regulation and traffic management.

FA1 Digitalisation & Innovation of the CEDR's Action Plan encompasses activities related to Connected and Automated Driving, Future Transport and Innovation Activities. Specific objectives are providing the 'eyes and ears' of CEDR and NRAs with regard to European and global developments in a fast-moving domain of ITS and connected & automated transport. This will provide the understanding about the implications of automatic driving for the NRAs from all points of view: investments required; liabilities (in case of accidents); delays and congestion; and legal implications.

CEDR recognizes that national road authorities can benefit greatly from CAD if it can be implemented for improving policy objectives of safe, reliable, efficient and environmentally friendly mobility in the face of traffic growth, ageing infrastructure and limited public financing. Since October 2019, the Connected and Automated Driving (CAD) working group of CEDR has been actively contributing to the developments and representing the interests of national road authorities (NRAs).

The working group is organised into 3 task groups: Data, Infrastructure and Impact on Transportation

More information about CEDR CAD WG:

- CEDR website
- CEDR brochure
- National Road Authority Connected and Automated Driving strategy 2018 -2028

9.11. DATEX II

DATEX II is a standardised e-language for traffic and travel data exchange between traffic control centres, traffic information centres and service providers. The European Commission describes the DATEX II standard as a reference standard in several Delegated Regulations supporting the ITS Directive and ITS Action Plan.

The DATEX II organisation governs and maintains the DATEX II standards, the accompanying documentation and provides user support to the user community. It is hosted by CEDR. The DATEX II organisation is open to all stakeholders in the traffic and travel domain that want to participate in the maintenance and user support of DATEX II.

The project organisation of DATEX II is structured in three layers:

- The Steering Group (SG) has the final responsibility for all decisions in the project. A Stakeholder Advisory Board (STAB) that advises (asked or not) the SG. The STAB consists of public or private organisation that want to be linked to the project.
- The Technical Management Group consists of technical experts that deal with the day-to-day management and development of the DATEX II standards, documentation and support.
- The Activity teams led by Activity Leaders. Members of these teams are the experts from the different DATEX II partners and other organisations that actively participate in the Activities.

Activity 7 of the DATEX II Programme Support Action (PSA) - 'C-ITS Harmonisation' - focuses on the developments in the domain of Cooperative-ITS (C-ITS) and especially its effect on information provision to and from road operators transferring data via DATEX II. Where information elements are used in both domains, DATEX II and C-ITS, or target the same domain concepts, it is crucial that definitions are harmonised. The DATEX II PSA ended mid-2021, but the work will be continued in the NAPCORE PSA (National Access Point Coordination Organization for Europe) from mid-2021 to December 2024.

More information about DATEX II:

- DATEX II website
- DATEX II Activity 7: C-ITS Harmonisation
- DATEX II Documentation Portal or Academy

9.12. Technical Committee (TC) Intelligent Transport System (ITS) of ETSI

ETSI is a European Standards Organization (ESO). ETSI produces globally applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, aeronautical, broadcast and internet technologies and is officially recognized by the European Union as a European Standards Organization. ETSI is an independent, not-for-profit association whose more than 700 member companies and organizations, drawn from 62 countries across 5 continents worldwide, determine its work programme and participate directly in its work.

The ITS Technical Committee (TC ITS) is leading the drive to global standards that will support applications including road safety, traffic control, fleet management and location-based services, driver assistance, hazard warnings and assistance to emergency services. Scope of the committee's work includes communication media, and associated physical layer, transport layer, network layer, security, lawful intercept and the provision of generic web services. As well as developing standards related to the overall communication architecture, management, security and conformance testing, we are also closely involved in related spectrum requirements for ITS.

The activity of TC ITS is organised in 5 Working Groups:

1. TC ITS Working Group 1 (WG1) Application requirements and services
   It addresses applications and services for ITS, including requirements from passengers, automotive industry, road network operators; freight/logistics actors and public authorities.
2. TC ITS Working Group 2 (WG2) Architecture and cross-layer
   It considers overall architecture and cross layer issues relating to ITS.
3. TC ITS Working Group (WG3) Transport and network
   It focuses on data transport and network protocol aspects of ITS.
4. TC ITS Working Group 4 (WG4) Media and medium
   It has as primary responsibility to encompass ITS standardization on OSI model layers 1 and 2.
5. TC ITS Working Group (WG5) Security
   It works on issues such Trust and Privacy Management.

More information about ETSI's TC on ITS:

- TC ITS Activity Report 2020
- ETSI ITS published standards
- ETSI website

Apart from ETSI, CEN and ISO are also important actors in C-ITS standardisation (e.g. CEN TC 278 WG 16, ISO TC 204 WG 18).

9.13. C-ITS Deployment Platform (inactive)

This initiative is not active anymore.
The C-ITS Deployment Platform was initiated by the European Commission DG Mobility and Transport (DG MOVE) mid 2014. The task of the C-ITS Platform was to assist the Commission in the development of a shared vision and a roadmap for the deployment of C-ITS in the EU.

Phase 1 of the C-ITS Deployment Platform was completed early 2017 with the publication of the C-ITS Platform Final Report in January 2017. It describes the services likely to be introduce in the first stage (Day 1 applications).

Phase 2 of the C-ITS Deployment Platform has been completed in 2018. The second phase of the platform further developed a shared vision on the interoperable deployment of Cooperative Intelligent Transport Systems (C-ITS) towards cooperative, connected and automated mobility (CCAM) in the European Union.

More information on the C-ITS Deployment Platform:

- Information on the C-ITS Deployment Platform and report on WG meetings
- Final report of the C-ITS Deployment Platform – Phase I (2016)
- Annexes to the final report – Phase I (2016)
- Final report of the C-ITS Deployment Platform - Phase II (2017)
- Annexes to the final report - Phase II (2017)

9.14. Other relevant actors and projects

Apart from the main C-ITS initiatives mentioned in the previous sections, a range of other actors is relevant when looking at the C-ITS domain. A list of these actors is included in Annex 1. A list of relevant C-ITS projects is included in Annex 2. Annex 3 provides an overview of additional interesting reading material on C-ITS.

10. Overview of relevant information in relation to C-ITS clusters

Based on the various Working Groups, Work Packages and Strategic Issues distinguished in the work of the organisations described in Chapter 9, five Clusters have been defined. The clusters are used to classify the various reports and other sources of information from the initiatives:

1. Harmonization Cluster: covers a range of technical and functional strategic issues, such as hybrid communication, bandwidth, spectrum, digital infrastructure, interoperability, compliance, standardization and integration;
2. Horizontal Cluster: covers issues that arise in the design of new mobility systems and services, such as organisational aspects, urban mobility, financial risks, new investment and business models, public acceptance and international cooperation, as well as data and knowledge sharing;
3. Legal Cluster: addresses strategic issues in relation to the C-ITS legal framework, data protection, privacy, security and certification;
4. Assessment and roadmap Cluster: focusses on the assessment of (among others) safety challenges, evaluation of the impact of C-ITS deployments on the transport system, non-equipped users, interoperability, cross-site testing, identification of use cases and roadmaps.

In this section for each of the cluster described above the following items will be presented:

Organization	Activity	Objective(s)	Relevant documents/websites
CCAM Single Platform; Amsterdam Group; The European Data Task Force; C-Roads, 5GAA; C2C-CC; C-ITS Deployment Group; The sub-group on C-ITS of the Commission Expert Group on Intelligent Transport Systems; CEDR's CAD WG; DATEX II; Technical Committee (TC) Intelligent Transport System (ITS) of ETSI	Relevant Working Groups, Work Packages, Strategic Issues	The objectives of the specific Working Groups, Work Packages, Strategic Issues	Links to the relevant documents or websites where more information can be found about the topic

10. Overview of relevant information in relation to C-ITS clusters -- HARMONIZATION CLUSTER

HARMONIZATION CLUSTER			
The harmonization cluster focusses on a range of technical and functional strategic issues. In terms of technical issues, the following topics are included: hybrid communication, bandwidth, (real-time) data, radio spectrum & frequencies, digital infrastructure and matching technologies with services. In terms of functional strategic issues, the following topics can come to mind: interoperability, compliance, standardisation and integration of systems & services.			
Organization	**Activity**	**Objective(s)**	**Relevant documents/websites**
C-Roads Platform	WG2: Technical Aspects	Four objectives can be identified. 1) To give recommendations on driver information through C-ITS services, 2) The harmonisation of current and future C-ITS services (Day 1, Day 1.5 and later), 3) To contribute to the definition and implementation of a harmonised communication profile for C-TIS pilot services on road infrastructures all across Europe, 4) To take existing standards in the drafting of specifications into account and to contribute with new and/or updated items to the standardisation processes.	Work Group Technical Aspects
	WG2 (TF2): Service Harmonisation	The ultimate goal of this work is a common understanding of the functionality of Day-1-C-ITS-services, the underlying architectures and the responsibilities of all stakeholders. C-Roads will deal with the common points for deployment as well with those, where harmonisation is needed.	Work Group Technical Aspects Task Force Service Harmonisation
	WG2 (TF3): Infrastructure Communication	Roadside infrastructure will share data and services with vehicles about the traffic status and events. Since the data to be communicated is of different nature, but needs to compliant to certain security specifications, different communication standards and technologies will have to be aligned in order to ensure proper data exchange across various kinds of borders. Hereby the C-Roads Platform is following the hybrid communication approach, starting with ETSI ITS-G5 and existing cellular networks.	Work Group Technical Aspects Task Force Infrastructure Communication

	WG2 (TF4): Hybrid Communication	The work in C-roads WG2 has been initially focused on short range communication and setting up the scenarios. However, C-Roads also has an obligation regarding long range communication. Both solutions have high relevance due to the different character of the European road transport system i.e. densely and not so densely populated areas. There are of course also different national strategies for deployment of C-ITS services. To cater for long range communication and associated issues, TF4 “Hybrid communication” was established. Sweden has volunteered for the leadership due to their NordicWay 2 obligations. One important issue is to consider how to take advantage of work done so far when engaging in new challenges.	Work Group Technical Aspects Task Force Hybrid Communication
	WG4: Urban C-ITS harmonisation	WG4 is dedicated to City Authorities interested in the C-Roads Platform. These cities can discuss between themselves (with the support of the C-Roads Platform partners) their specific requirements for the C-ITS roll out. Here a reflection of the platform work already done will be performed with a clear focus on changes/adoptions that need to be made on existing publications to make them applicable as well for urban areas. The output of the work will not be a single report, but inputs to the work already undertaken by existing C-Roads Platform groups. In addition, the Urban Working Group is expected to work together towards strategies for the introduction of harmonised C-ITS services in urban areas. The main topics are C-ITS aspects of high relevance to cities like public transport priority at traffic lights or dynamic parking management. The benefit of WG4 will be to have one interface with the OEMs facilitate support services delivered by city authorities.	Work Group Urban C-ITS harmonisation
	WG5: Digital Transport Infrastructure (DTI)	The DTI Working Group will focus on the infrastructure needs for a digital infrastructure as a whole, including Traffic Management as well as HD maps. Existing standards will be reflected (TN-ITS and/or the work on METR -	Work Group Digital Transport Infrastructure

		Management for Electronic Traffic Regulations) and recommendations to infrastructure operators will be given. A close liaison with ongoing initiatives (e.g. DATEX II) is foreseen to produce recommendations.	
5G Automotive Association - 5GAA	WG1: Use Cases and Technical Requirements	Define end-to-end view on use cases and derive technical requirements and performance indicators for the certification of connected mobility solutions (e.g. on communication architecture, radio protocols, radio parameters, frequency spectra and carrier aggregation combinations). Ensure interoperability for V2X and other affected technologies.	5GAA Working Groups
	WG2: System Architecture and Solution Development	Define, develop and recommend system architectures and interoperable end-to-end solutions to address use cases and Services of Interest. Reviewing currently available solutions in technical areas such as wireless air interface technologies, wireless network deployment models, radio access networks and networked clouds, connectivity and device management or security, privacy and authentication.	5GAA Working Groups
	WG4: Standards and Spectrum	Act as 'Industry Specification Group', providing recommendations, contributions and positions to ETSI, 3GPP and other standards development organisations. Agree on spectrum requirements for V2X in ITS, MBB and unlicensed bands. Represent the association vis-à-vis other industry organisations.	5GAA Working Groups
CCAM Single Platform	WG6: Connectivity and digital infrastructure for CCAM	This working group aims to: • Support the coordination of activities that focus on telecommunication infrastructure. • Identify how satellite navigation can support the pre-deployment of automated vehicles;	CCAM 1st Plenary Meeting CCAM 2nd Plenary Meeting WG Meetings

		• Gather and exchange experiences, best practices and knowledge on how spectrum can be efficiently allocated to various technologies; • Promote collaboration regarding communication technology, both long-range and short-range; to coordinate testing and pre-deployment activities; • Address technical and legal issues that are relevant to data storage and cloud access; Carry out an assessment of the state-of-play how online platforms influence communication technologies.	
The CAR 2 CAR Communication Consortium - C2C – CC	Harmonisation and standardisation	One of the main objectives of C2C – CC is to support worldwide harmonisation and promotion of C-ITS as far as required enabling C-ITS to exploit its full potential. Therefore, the C2C-CC contributes to European and International standardisation and harmonisation activities for development of technical specifications, required for Cooperative Intelligent Transport System (C-ITS), including V2X (vehicle-to-everything) communication.	C2C – CC
DATEX II	Activity 7: C-ITS harmonisation	Activity 7 of the DATEX II Programme Support Action (PSA) - 'C-ITS Harmonisation' - focuses on the developments in the domain of Cooperative-ITS (C-ITS) and especially its effect on information provision to and from road operators transferring data via DATEX II. Where information elements are used in both domains, DATEX II and C-ITS, or targeting the same domain concepts, it is crucial that definitions are harmonised. One major task of Activity 7 is to analyse the requirements coming from C-ITS domain to DATEX II. It is intended to analyse if modifications of the DATEX II model are required and potentially determine modifications and requirements for new DATEX II elements in order to enable interoperability with C-ITS systems.	Activity 7 DATEX II

Technical Committee (TC) Intelligent Transport System (ITS) of ETSI	WG1: Application requirements and services	It addresses applications and services for ITS, including requirements from passengers, automotive industry, road network operators; freight/logistics actors and public authorities. In April 2019 new versions of the CAM (Cooperative Awareness basic service) and DENM (Decentralized Environmental Notification basic service) were published. These extend CAM and DENM for the support of LTE-V2X Access Layer, maintaining backward compatibility with ITS-G5 Access Layer. Work was also initiated to update CAM and DENM test specifications.	TC ITS Activity Report 2019 TC ITS WG1 Deliverables
	WG2: Architecture and cross-layer	It considers overall architecture and cross layer issues relating to ITS. The focus is on C-V2X and potential future radio technologies for V2X, namely: • Investigating enhancements to the architecture for communications among ITS stations with multiple access layer technologies • Investigating interoperability and backward compatibility when implementing future ITS systems (e.g. C-V2X) The WG continued to update a TR on the Framework for Public Mobile Networks in Cooperative ITS, taking into account the recent development of mobile network technologies.	TC ITS Activity Report 2019 TC ITS WG2 Deliverables
	WG3: Transport and network	It works on data transport and network protocol aspects of ITS, publishing an update of its EN on geonetworking to incorporate support for LTE-V2X.	TC ITS Activity Report 2019 TC ITS WG3 Deliverables
	WG4: Media and medium	It has as primary responsibility to encompass ITS standardization on OSI model layers 1 and 2, including the management of these layers. Core WG 4 subject areas currently include:	TC ITS Activity Report 2019 TC ITS WG4 Deliverables

		• Liaison/participation with regard to TC ERM scoped issues, where WG 4 is the group responsible inside TC ITS for development of ETSI System Reference documents for ITS • 5 GHz and 60 GHz spectrum bands • Infrared CEN RTTT DSRC ISO CALM (21212 and 21213) 2G/3G	
Amsterdam Group	WG2: System specification profiling	The objective of this WG is to analyze the in-car C-ITS system specification and white papers and define a roadside C-ITS system specification document.	Amsterdam Group
	WG4: Radio spectrum & frequencies	The objective of this WG is to monitor and give input to the work already ongoing related to frequency allocation and sharing.	Amsterdam Group
	WG7: Conformance assessment	This WG focusses on developing, together and based on the work performed in the C2C CC an end-to-end testing approach for road side C-ITS.	Amsterdam Group
	WG8: Hybrid Communication Concept	Next to short range communication between vehicles and road infrastructure, also complementary technology (cellular systems, broadcasting systems) could / will play a role in C-ITS. This work group focusses on making these approaches converge.	Amsterdam Group
	WG9: Backend Services	The interconnection between traffic control centres, the Central C-ITS systems and roadside systems gives a big potential for harmonisation between the different corridors. This WG aims to identify the current situation in the corridor countries and provide a proposal for harmonisation steps.	Amsterdam Group

10. Overview of relevant information in relation to C-ITS clusters -- HORIZONTAL CLUSTER

HORIZONTAL CLUSTER			
The horizontal cluster focusses on strategic issues that arise in the design of new mobility systems and services, such as organisational aspects, urban mobility, financial risks, new investment and business models, public acceptance and international cooperation, as well as data and knowledge sharing.			
Organization	**Activity**	**Scope and objective(s)**	**Relevant documents/websites**
CCAM Single Platform	WG2: Coordination and cooperation of R&I	The main objectives of this WG are: • Improve exchange of knowledge and experience • Facilitate data sharing of tests • Develop common approaches for testing and assessing impacts The activities of this group focus on: • Setting-up a knowledge base to gather and exchange experiences, best practices and knowledge on pilots, demonstrations and large-scale trials. • Develop a common evaluation methodology to allow for comparison of results between tests. This includes establishing key performance indicators and a common framework for the assessments of impacts. • Identify how access to, and exchange of data for and through testing and pre-deployment activities can be facilitated. Assist in establishing a data governance framework in this context.	CCAM 1st Plenary Meeting CCAM 2nd Plenary Meeting WG Meetings
	WG3: Physical and digital road infrastructure	The main objectives of this working group are: • To understand the role of infrastructure in CCAM • To identify investment priorities, or to provide guidance on how to prioritise such investments • To contribute to the exercise carried out by WG1: R&I actions. • Identify Operational Design Domains and related digital and physical infrastructures that can support which CCAM use cases. Identify what technical and policy challenges exist when discussing digital and physical infrastructure for CCAM. What research is needed to address these challenges?	CCAM 1st Plenary Meeting CCAM 2nd Plenary Meeting WG Meetings

The European Data Task Force - DTF	Cooperation for data sharing	The EU strategy on connected and automated mobility looks at a new level of cooperation between road users with potential enormous benefits for the mobility system. The ITS directive (2010/40/EU) and sequential delegated acts further support this development. The SRTI Ecosystem partners, a system developed by the DTF, will make a collaborative effort to be part of this new cooperation and share data while supporting road safety. One of the core principles of DTF is enhancing and intensifying corporation on safety-related traffic information in order to increase road safety.	Data Task Force and successor Data for Road Safety Initiative
C-Roads Platform	WG1: Organisational aspects	This WG focuses on analysing and describing the cooperation needed for the roll-out of C-ITS in different organisational environments in Europe. In addition, the WG will collect and investigate solutions to overcome known and newly identified legal barriers and obstacles related to C-ITS. This WG will also work on collecting and exchanging of business models for the deployment of C-ITS infrastructures.	Work Group C-ITS Organization
CEDR's CAD WG	TG Data	One of the main strategic scope of the TG Data is establishing a joint strategy for NRAs on data access and sharing. As part of this goal, they undertake the following organisational activities: • Achieving a common understanding of NRA needs with respect to access to data, data sharing and data quality for network management • Taking a stronger lead in what data NRAs request from OEMs/service providers, what data NRAs will provide to OEMs/service providers • Exchanging information with the EC and advising CEDR Member Countries on necessary actions including policy and legislation	CEDR site

	TG Infrastructure	TG Infrastructure focuses on various issues related to the digital and physical infrastructure, from a technical, functional, policy and financial point of view. Its main activities are: • Identifying digital infrastructure architecture, roles and responsibilities and investments • Adapting physical infrastructure for higher level automated driving • Identifying and establishing resources needed, including 'conventional' TM assets • Identifying stakeholders and responsibilities: who should be responsible for what? Developing shared investment and funding models with the industry, for specific use cases (combining connected, cooperative services and automation)	CEDR site
C-ITS Deployment Group	C-ITS Deployment good practices Research Pilot sites	C-ITS Deployment Group focuses on the importance for C-ITS deployment from various perspectives: road safety, efficiency, tackling congestion, cooperation, policy, etc. Their aim is to increase road safety and decrease congestions on Europe´s motor- and expressways by deploying C-ITS. To this end, they focus on three main activities: • Research • Pilot sites Good practices	C-ITS Deployment Group Activities

European ITS Platform

10. Overview of relevant information in relation to C-ITS clusters -- LEGAL CLUSTER

LEGAL CLUSTER			
The legal cluster focusses on strategic issues in relation to the C-ITS legal framework, data protection, privacy, security and certification.			
Organization	**Activity**	**Objective(s)**	**Relevant documents/websites**
CCAM Single Platform	WG5: Cybersecurity and access to in-vehicle data linked to CCAM	The main scope of work for the WG5 is focusing on how testing and pre-deployment activities can be used: • To ensure security of CCAM vehicles against cyber threats for car manufacturers and other actors of the smart mobility ecosystem • Identify how secure access to, and secure exchange of, vehicle and infrastructure data (including instructions) has been and may be facilitated over the full lifecycle of the components of the ecosystem • To find a common understanding for addressing technical and legal issues that are relevant for the access, transfer, sharing, use and storage of data • The group will also promote collaboration between the various actors to ensure high quality standards and accuracy of data, and compliance with the Regulation on Free flow of Non-personal Data	CCAM 1st Plenary Meeting CCAM 2nd Plenary Meeting WG Meetings
C-Roads Platform	WG2 (TF1): Security Aspects	This Task Force deals with security specifications, which need to be considered by deploying C-ITS services, ensuring secure data and service exchange between infrastructure and vehicles. Security solutions need to be in place because of a broad group of reasons, ranging from privacy issues to terror attacks.	Work Group Technical Aspects Task Force Security Aspects
5G Automotive Association - 5GAA	WG6: Regulatory and Public Affairs	The working group focuses on agreeing on common 5GAA positions in relation to policy and regulatory matters at a national, regional and (whenever possible) global level to secure market access, foster technology innovation and investment, and support commercial deployment, developing a common policy strategy among industry stakeholders, public authorities, and subject matter expert members.	5GAA Working Groups

	WG7: Security and Privacy	Review currently available solutions in relevant technical areas and identify gaps towards comprehensive secure end-to-end solutions and specifications for the use cases and services of interest as defined by the "Use Cases and Technical Requirements" WG.	5GAA Working Groups
The sub-group on C-ITS of the Commission Expert Group on Intelligent Transport Systems	(Cyber)security	In the EU Strategy for mobility of the future, the Commission set out a specific action to implement a pilot on common EU-wide cybersecurity infrastructures and processes needed for secure and trustful communication between vehicles and infrastructure for road safety and traffic management related messages according to the published guidance on the certificate and security policy. To successfully implement this pilot on common EU-wide cybersecurity infrastructures and processes, there is the need to set-up a sub-group on Cooperative Intelligent Transport Systems (C-ITS) under the Commission Expert Group on Intelligent Transport Systems.	Commission Expert Group on C-ITS EU C-ITS security credential management system (EU CCMS) Call for applications for the selection of members of the sub-group on Cooperative Intelligent Transport Systems of the Commission Expert Group on Intelligent Transport Systems
Technical Committee (TC) Intelligent Transport System (ITS) of ETSI	WG5: Trust and Privacy Management	TC ITS WG5 focuses on security aspects and has been working on revisions of its existing TS on Trust and Privacy Management.	TC ITS Activity Report 2019 TC ITS WG5 Deliverables
Amsterdam Group	WG1: Security	It is to be verified if the approach of C2C CC is applicable as well for Road Administrations which will run the road side installations for C-ITS. A harmonisation of the approach is the aim of this WG.	Amsterdam Group
	WG3: Consistency of legal framework	C-ITS can be operated only under an adequate legal framework on national and EU level. The work in this respect requires the analysis of e.g. privacy and other laws impacting the introduction of Day One use cases.	Amsterdam Group

10. Overview of relevant information in relation to C-ITS clusters -- ASSESSMENT & ROADMAP CLUSTER

ASSESSMENT & ROADMAP CLUSTER			
The assessment & roadmap cluster focusses on strategic issues dealing with the assessment of safety challenges, the evaluation of the impact of C-ITS deployments on the transport system, non-equipped users, interoperability, cross-site testing, identification of use cases (Day One, Day two), and roadmaps.			
Organization	**Activity**	**Objective(s)**	**Relevant documents/websites**
C-Roads Platform	WG2 (TF5): Cross-Testing and Validation (TF5)	To execute cross-testing and validation between two or more pilots, each pilot has to fulfil certain prerequisites. In general, a service designated for cross-testing has to be implemented and successfully tested at the pilot level. A set of requirements for a pilot to participate on a cross-testing and validation will be derived. This Task Force deals with the necessary steps to ensure interoperability as well as the preconditions for cross-testing and validation and shall touch upon the different testing levels (on-lab, on closed test tracks and on open roads) and the test subjects (security, message payload and transmission/reception). The work will also focus on how to execute the cross-tests in the course of harmonised test cases.	Work Group Technical Aspects Task Force Cross-Testing and Validation
	WG3: Evaluation and Assessment	This WG defines how cross-site tests as well as evaluation are done and which aspects (safety, efficiency, etc.) are assessed in which pilots. This includes: 1) Transmitting the achievements of the tasks completed in other WGs to practical environments and also collecting findings from these environments with the overall goal of interoperability and C-ITS service harmonisation, 2) Defining a methodology and performing cross-site tests all across Europe, and 3) Assessing the impact of the C-ITS services in terms of interoperability, sustainability, safety, efficiency, and environmental aspects.	Work Group Evaluation and Assessment

5G Automotive Association - 5GAA	WG3: Evaluation, Testbeds, and Pilots	Evaluate and validate end-to-end solutions through testbeds. Globally orchestrating and harmonising conformity and interoperability assessments to ensure that new C-V2X products conform to existing standards and are interoperable with each other. Manage regional interoperability event programmes in cooperation with regionally established organisations. Promote commercialisation and standardisation via pilots and large-scale trials by selecting the use cases in conjunction with go-to-market strategies. This includes multi-phase / multi-year planning with prioritisation.	5GAA Working Groups
	WG5: Business Models and Go-To-Market Strategies	The WG has the following tasks: • Agree on criteria for business models. Identify involved organisations and companies and prioritise them. • Draft exemplary go-to-market plan as straw man function for agreed use cases under test and business models. Agree on how to best achieve a global approach to certification of the target connected mobility solutions.	5GAA Working Groups
CCAM Single Platform	WG1: Develop an EU agenda for testing	The main activities of the working group are focused on: • The definition of common priority use cases; • Identification of all functionalities, technical and non-technical enablers and other pre-requisites to make progress with these use cases • Translating these priorities in an EU agenda for testing, serving as input for the creation of a European Partnership on CCAM The work will continue on: • Complete the European Research & Innovation agenda • Define the scope of R&I actions that should be addressed in the European Partnership	CCAM 1st Plenary Meeting CCAM 2nd Plenary Meeting WG Meetings
	WG4: Road safety	The scope of this working group is to analyse how testing and pre-deployment activities can be used to:	CCAM 1st Plenary Meeting

		• Identify current testing and pre-deployment activities that are relevant for road safety. • Identify road safety gaps that can benefit from testing/pre-deployment activities. • Coordinate testing and pre-deployment activities related to road safety • Promote good practices for testing and pre-deployment activities (code of conduct, approximation of test authorization national rules) • Promote collaboration between the different road safety actors with testing/pre-deployment activities. • Fuel the policy discussion on road safety rules (code of practice, driving licence, traffic rules, etc.) on the basis of lessons learnt in testing and pre-deployment activities. Ensuring that road safety aspects are included in testing and pre-deployment activities.	CCAM 2nd Plenary Meeting WG Meetings
CEDR's CAD WG	TG Transport impact system	The Task Group Transport impact system is responsible for the following activities: • Creating a practical & holistic view on the transport system impact • Describing on a functional level the future automated transport system, distinguishing between urban roads, highways and rural areas if relevant • Developing a shared vision on future network operation (in cooperation with the ETM group) • Coordinated testing of CAD on public roads: identifying research questions together and what tests may provide the answers Identifying what is needed for wider deployment and upscaling of CAD	CEDR site
Amsterdam Group	WG5: Deployment / Roll-out Day 1	The corridor initiatives related to C-ITS have different use cases as their priority for Day One. This WG aims to identify and give an overview on the different day one use cases and identify similarities and try to harmonise them.	Amsterdam Group

	WG6: Roadmap beyond Day One	The Amsterdam Group has identified a set of Day One Applications. This WG will come up with considerations what could be Use Cases for Day Two and further on.	Amsterdam Group
	WG10: Use Cases	The AG members have agreed on a set of specific use cases which are supported by OEMs and road operators. The aim of this WG is to define detailed functional specifications of these specific use cases and identify harmonisation / standardisation needs.	Amsterdam Group

Annex 1: Overview of relevant organisations

In chapter 9, the main C-ITS initiatives have been described. A range of other actors is also relevant when looking at the C-ITS domain. These actors are briefly described in this annex.

Project category	Name	Website link	Description
European Commission	DG MOVE - C-ITS Platform (phase I and II)	https://transport.ec.europa.eu/transport-themes/intelligent-transport-systems/cooperative-connected-and-automated-mobility-ccam_en	ITS Directive, EU C-ITS Strategy, planned Delegated Act on C-ITS
	DG Research - Strategic Research and Innovation Agenda (STRIA)	http://ec.europa.eu/programmes/horizon2020/en/news/towards-strategic-transport-research-innovation-agenda-stria	One of the themes of STRIA is 'Connected and Automated Driving'.
	DG Connect - Roundtable on Connected and Automated Driving	https://ec.europa.eu/digital-single-market/en/news/eu-commissioner-oettinger-holds-roundtable-automated-driving-frankfurt	A cross-sectorial dialogue between automotive and telecommunication/IT industry to join forces on fast and coordinated deployment of future-proof communication systems and increasing levels of automated driving. It was initiated by the Commissioner Oettinger, responsible for Digital Economy and Digital Society. Also known as Oettinger Round Table.
	DG Internal Market, Industry, Entrepreneurship and SMEs - GEAR 2030	http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8640&lang=en	The GEAR 2030 High Level Group was established by the EC in January 2016 and will focus on three areas of work: (1) the adaptation of the value chain to new global challenges, (2) the automated and connected vehicles, (3) trade, international harmonisation and global competitiveness.

	European Climate, Innovation and Environment Executive Agency (CINEA)	https://cinea.ec.europa.eu/index_en	Agency of the European Commission dedicated to funding many EU projects, including projects in the field of C-ITS
	General Data Protection Regulation	https://gdpr.eu/	The EU General Data Protection Regulation (GDPR) replaces the Data Protection Directive 95/46/EC and was designed to harmonize data privacy laws across Europe, to protect and empower all EU citizens data privacy and to reshape the way organizations across the region approach data privacy.
	EU Data Protection Authorities	http://ec.europa.eu/justice/data-protection/article-29/structure/data-protection-authorities/index_en.htm	Links to all national data protection authorities in the EU
Standardisation institutes	Comité Européen de Normalisation (European Committee for Standardisation(CEN)	https://www.cen.eu/work/areas/transport/ITS/Pages/default.aspx	
	International Standards Organisation (ISO)	https://www.iso.org/committee/54706.html	
	Transport Protocol Expert Group (TPEG)	http://tisa.org/wp-content/uploads/documents/TISA14001TPEGWhatisitallabout2014.pdf	The Transport Protocol Experts Group (TPEG) is a data protocol suite for traffic and travel related information. TPEG can be carried over different transmission media (bearers), such as digital broadcast or cellular networks (wireless Internet). TPEG is managed by TISA.

European and international Telecom organisations	UN International Telecommunication Union (ITU)	http://www.itu.int/en/about/Pages/default.aspx	ITU is the United Nations specialized agency for information and communication technologies – ICTs.
	European Conference of Postal and Telecommunications Administrations (CEPT)	https://cept.org	The Electronic Communications Committee of the CEPT considers and develops policies on electronic communications activities in European context, taking account of European and international legislations and regulations.
	5G Infrastructure Public Private Partnership (5G PPP)	https://5g-ppp.eu	The 5G Infrastructure Public Private Partnership, in short 5G PPP, has been initiated by the EU Commission and industry manufacturers, telecommunications operators, service providers, SMEs and researchers. In the 5G PPP, the 5G Infrastructure Association (5G IA) represents the private side and the European Commission the public side. The 5G IA is committed to the advancement of 5G in Europe and to build global consensus on 5G.
	3rd Generation Partnership Project (3GPP)	http://www.3gpp.org/about-3gpp	The 3rd Generation Partnership Project (3GPP) unites [Seven] telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as “Organizational Partners” and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies.

C-ITS stakeholder organizations	Conference of European Directors of Roads (CEDR)	http://www.cedr.eu	Platform for cooperation between National Road Authorities
	Association Européenne des Concessionnaires d'Autoroutes et d'Ouvrages à Péage (ASECAP)	http://www.asecap.com	ASECAP is the European Association of Operators of Toll Road Infrastructures
	POLIS	http://www.polisnetwork.eu	Polis is a network of European cities and regions working together to develop innovative technologies and policies for local transport.
	ERTICO - ITS Europe	http://ertico.com	ERTICO - ITS Europe is a partnership of around 100 companies and institutions involved in the production of Intelligent Transport Systems (ITS).
	Traveller Information Services Association (TISA)	http://tisa.org	TISA is a market-driven membership association with worldwide scope, established as a non-profit company focussed on proactive implementation of traffic and travel information services and products based on existing standards, including primarily RDS-TMC and TPEG technologies.
	European Automotive-Telecom Alliance (EATA)	https://eata.be/	The Alliance includes six leading sectorial associations, as well as 37 companies, including telecom operators, vendors, automobile manufacturers and suppliers for both cars and trucks. The main goal of this Alliance is to promote the wider deployment of connected and automated driving in Europe.
	European Automobile Manufacturers Association (ACEA)	http://www.acea.be	ACEA is an advocate for the automobile industry in Europe, representing manufacturers of passenger cars, vans, trucks and buses with production sites in the EU.

	CCAM Partnership and CCAM Association	https://www.ccam.eu/	The CCAM Partnership is a cooperation between the European Commission and private and public stakeholder in the CCAM domain, with the aim to carry out the CCAM Strategic Research and Innovation Agenda (SRIA). The Partnership will start beginning of 2021: a new association is created in autumn 2020, to gather the interested stakeholders and be ready to support the Partnership activities.

Annex 2: Overview of relevant C-ITS projects

This annex provides an overview of mostly European C-ITS projects, both running and finished projects.

As the project landscape evolves very fast, this table (original version 2017) is unfortunately **not up to date** and even some website links are not accessible.

Project category	Name	Website link	Description
C-ITS deployment initiatives	A2/M2 Connected Vehicle Corridor	http://www.codecs-project.eu/fileadmin/user_upload/pdfs/Workshop_C-ITS_Deployment_underway_II/Hanson_InterCor_UK.pdf	London to Dover connected vehicle corridor
	C-ITS Pilot in Hungary	http://www.codecs-project.eu/fileadmin/user_upload/pdfs/Workshop_C-ITS_Deployment_underway_II/Tomaschek_C-ITS_pilot_Hungary.pdf	C-ITS deployment in Hungary
	CITRUS	https://www.citrus-project.eu	CITRUS's main focus is the development of a companion app for truck drivers which enhance road safety and improve logistics efficiency, based on a cellular C-ITS approach in combination with geo-fencing .
	City projects with involvement POLIS	http://www.polisnetwork.eu/topics/48/38/Cooperative-ITS-C-ITS?topic=true&topics=48	Overview of C-ITS projects in which POLIS participates (urban C-ITS)
	Cogistics	http://cogistics.eu	Focus on the deployment of cooperative ITS services for logistics.

Compass4D	http://www.compass4d.eu http://www.compass4d.eu/en/results/	C-ITS deployment in seven European cities (Bordeaux, Copenhagen, Helmond, Newcastle, Thessaloniki, Verona and Vigo)
Cooperative ITS corridor	C-ITS Corridor Germany: http://www.c-its-korridor.de/?menuId=1&sp=en C-ITS Corridor Austria: http://eco-at.info/home-en.html C-ITS Corridor Netherlands: https://itscorridor.mett.nl/default.aspx	Cooperative corridor Netherlands - Germany - Austria
Deployment in the Czech Republic	http://www.codecs-project.eu/fileadmin/user_upload/pdfs/Workshop_C-ITS_Deployment_underway_II/Volny_Czech_Republic.pdf	C-ITS deployment in Czech Republic
DITCM testsite	http://www.ditcm.eu	Testsite for connected mobility in The Netherlands
French corridor pilot project Paris-Strasbourg	https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/projects-by-country/multi-country/2014-eu-ta-0669-s	C-ITS corridor Paris-Strasbourg
INTERCOR	http://www.c-roads.eu/	Intercor aims to connect the C-ITS corridor initiatives of the C-ITS Corridor Netherlands-Germany-Austria, the French corridor project SCOOP@F, and the UK and Belgian C-ITS initiatives.
NordicWay pilots	http://www.codecs-project.eu/fileadmin/user_upload/pdfs/Workshop_C-ITS_Deployment_underway_III/3_1_Kotilainen_NordicWay.pdf	C-ITS deployment in Scandinavian countries

SCOOP@F	http://www.scoop.developpement-durable.gouv.fr/en	C-ITS services will be piloted on 5 locations in France
C-ROADS Austria	https://www.c-roads.eu/pilots/core-members/austria/Partner/project/show/c-roads-austria.html	300km of Austrian motorways connecting Vienna and Salzburg, th Brenner corridor and the surroundings of Graz will be equipped with C-ITS infrastructure.
C-ROADS Belgium / Flanders + InterCor	https://www.c-roads.eu/pilots/core-members/belgium-flanders/Partner/project/show/c-roads-belgium-flanders.html	Priority will be given to motorways surrounding Antwerp and segments towards the Netherlands
C-ROADS Czech Republic	https://www.c-roads.eu/pilots/core-members/czech-republic.html	C-ITS services will be piloted on more than 200 km of motorways connecting Prague with Brno, Hradec Kralove, Pilsen and further towards Germany in the direction to Nuremberg and towars Austria. Pilot sites in the cities of Pilsen, Brno and Ostrava will verify urban C-ITS use cases
C-ROADS Finland	https://www.c-roads.eu/pilots/associated-members/finland.html	Finland will provide experiences, expectations and requirements from the joint Nordic CEF funded NordicWay cellular/hybrid C-ITS project (www.nordicway.net), Finnish Coop pilot in the NordicWay (www.infotripla.fi/coop) and possible successor deployment projects for the C-Roads platform.

C-ROADS France + InterCor	https://www.c-roads.eu/pilots/core-members/france.html	The French C-ITS pilot deployment project is set up by 14 French beneficiaries covering the whole functional chain of C-ITS systems and services, including most partners of SCOOP@F but also cities, new road operators and academic partners. France is also part of the 4-country project InterCor to extend the coverage of SCOOP@F towards the North of France, with an additional focus on freight services.
C-ROADS Germany	https://www.c-roads.eu/pilots/core-members/germany.html	On motorways as well as on links to urban areas, C-ITS Day-1 services will be piloted in the Federal States of Lower Saxony and Hessen in public-private partnership of in total 17 beneficiaries.
C-ROADS Ireland	https://www.c-roads.eu/pilots/associated-members/ireland.html	Ireland has designated the M50 (Dublin Orbital Motorway) as a road where traffic and safety conditions require the deployment of a road safety-related traffic information service.
C-ROADS Slovenia	https://www.c-roads.eu/pilots/core-members/slovenia.html	100 km of the Slovenian core network will be equipped to pilot ITS-G5 as well as hybrid communication profiles to deliver C-ITS Day-1 Services.
InterCor - The Netherlands	https://www.c-roads.eu/pilots/core-members/netherlands.html	Along the motorway network from Venlo to Rotterdam as well as in the surrounding are of Utrecht C-ITS Day-1-services will be piloted with an additional focus on freight services.

	InterCor - United Kingdom	https://www.c-roads.eu/pilots/core-members/united-kingdom.html	The UK is focusing on C-ITS Day-1-services which will be piloted on the A2/M2 Corridor between London and Dover. A mix of communication systems, including hybrid solutions, will be deployed along different stretches of the Corridor.
ITS deployment initiatives	Arc Atlantique	http://arcatlantique.its-platform.eu	ITS corridor project from UK via Benelux, France, Spain to Portugal (limited C-ITS).
	Ursa Major	http://ursamajor.its-platform.eu	ITS corridor project from the Netherlands via Germany and Austria to Italy (limited C-ITS).
	MedTIS	https://medtis.its-platform.eu/content/med-tis	ITS corridor between Italy, France, Spain and Portugal (limited C-ITS).
	Crocodile	http://crocodile.its-platform.eu	ITS corridor project in Central Europe (limited C-ITS).
	NEXT-ITS	http://next-its.its-platform.eu	ITS corridor project in Scandinavian countries (limited C-ITS).
ITS horizontal projects	DATEX II	http://datex2.its-platform.eu	DATEX II is a standardised e-language for traffic and travel data exchange between traffic control centres, traffic information centres and service providers, increasing involved in C-ITS.
	EU ITS Platform (EU EIP), EIP, EIP+	https://its-platform.eu	European ITS Platform project, with limited attention for C-ITS.
Urban C-ITS projects	MAVEN	http://maven-its.eu/	**MAVEN** (Managing Automated Vehicles Enhances Network) aims to provide solutions for managing automated vehicles in an urban environment (with signalised intersections and mixed traffic).

	CoEXist	http://www.h2020-coexist.eu/cities/gothenburg/	CoEXist (May 2017 – April 2020) aims to prepare for the transition phase during which automated and conventional vehicles will co-exist on urban roads.
	CONDUITS		**CONDUITS** developed key performance indicators to assist European municipalities in taking decisions on ITS deployment and to facilitate the exchange of good ITS practice among cities
	VRUITS	http://www.vruits.eu/	**VRUITS** helps to improve safety and mobility of vulnerable road users (VRUs) through ITS applications.
New projects, with focus on C-ITS	C-ROADS Belgium/Wallonia	project will start end of 2017	
	C-ROADS Hungary	https://www.c-roads.eu/pilots/associated-members/hungary.html project will start end of 2017	
	C-ROADS Italy	project will start end of 2017	
	C-ROADS Portugal	project will start end of 2017	The Portuguese C-ITS pilots will deploy and test Day 1 and Day 1.5 services using hybrid communication technologies along 964 km of the Atlantic Corridor in Portugal, covering relevant sections of the Core and Comprehensive TEN-T Network and the urban nodes of Lisbon and Porto.
	C-ROADS Slovenia 2	project will start end of 2017	

	C-ROADS Spain	project will start end of 2017	
	C-ROADS NordicWay 2	Project will start end of 2017, follow-up/extension of NordicWay 1	
	CONCORDA	project will start end of 2017	
	SOCRATES 2.0	project will start end of 2017	
New projects, with some C-ITS	Arc Atlantique Phase 3	project will start end of 2017, follow up of Arc Atlantique Phase 2	
	CROCODILE 2	project will start end of 2017, follow-up/extension of CROCODILE 1	
	CROCODILE Croatia	project will start end of 2017, follow-up/extension of CROCODILE 1 in Croatia	
	MedTIS III	project will start end of 2017, follow-up/extension of MedTIS II	
	Ursa Czech Republic	project will start end of 2017, follow-up/extension of Ursa Major 2 in Czech Republic	
	Ursa Major Neo	project will start end of 2017, follow-up/extension of Ursa Major 2	
	North European cross-border ITS phase 3 - NEXT-ITS 3	project will start end of 2017	
Completed projects	CIMEC (2015-2017)	http://cimec-project.eu	CIMEC is a city focused project, which explores the role cooperative ITS systems (C-ITS) can play to support city

			authorities, both in managing their transport networks and the delivery of other transport-linked services.
	COOPERS (2006-2010)	http://cvt-project.ir/En/EnNewsDetail.aspx?SubjectType=99&InfoID=1056	COOPERS stands for **CO-OP**erative Syst**E**ms for Intelligent **R**oad **S**afety and is a European research and development (R&D) project.
	CVIS (2006-2010)	http://erticonetwork.com/project-news-cvis/	CVIS focuses on V2V and V2I communication. Each vehicle will be able to communicate the latest traffic information and safety warnings to road operators and other nearby vehicles using a multi-channel terminal with a wide range of potential carriers (GPRS, UMTS, WLAN or Wi-Fi, DSRC, infrared).
	DRIVE C2X (2011-2014)	http://www.drive-c2x.eu/project	DRIVE C2X lays the foundation for rolling out cooperative systems in Europe, leading to safer, more economical and more ecological driving.
	FOTsis (2011-2015)	http://www.fotsis.com	FOTsis is a largescale field testing of the road infrastructure management systems needed for the operation of seven close-to-market cooperative I2V, V2I & I2I technologies (the FOTsis Services), in order to assess effectiveness and potential for a full-scale deployment.
	SAFESPOT (2006-2010)	http://www.safespot-eu.org	SAFESPOT creates dynamic cooperative networks where the vehicles and the road infrastructure communicate to share information gathered on board and at the roadside to enhance the drivers' perception of the vehicle surroundings.
	SCORE@F (2010-2013)	http://www.scoref.fr (in French)	SCORE@F (Experimental Road Cooperative System @ France) is a collaborative research project, experimenting with cooperative road systems within a European experimental

			framework. Its purpose is to prepare a deployment of road cooperative systems in Europe on all types of road environments.
	simTD (2008-2013)	http://www.simtd.de/index.dhtml/enEN/index.html	The sim[TD] research project is shaping tomorrow's safe and intelligent mobility through researching and testing car-to-x communication and its applications in Germany.
	SISCOGA and related initiatives in Spain (2010-2013)	http://wiki.fot-net.eu/index.php/SISCOGA	SISCOGA is a FOT for C2X applications in Galicia (Spain) during 2010 and 2011. It is based on an intelligent corridor, making use of the existing road network. CTAG (Galician Automotive Technology Centre) and DGT (Traffic Management in Spain), through the Northwest Management Traffic Centre, use existing infrastructure (beacons, road posts…) to carry out the tests. Both roadside and more than 100 vehicles are equipped with the necessary hardware and software.
	SPITS - Strategic Platform for Intelligent Traffic Systems (2009-2011)	https://www.utwente.nl/ctit/research/research_projects/concluded/national/senternovem/spits/	SPITS aims at creating an open, scalable, real-time, distributed, sustainable, secure and affordable platform for cooperative ITS applications, evolving from existing infotainment systems.
	Testfeld Telematik (2011-2013)	http://www.eco-at.info/testfeld-telematik-220.html	Testfeld Telematik, in the greater Vieanna area, was focused spatial and technical on the high-ranking road network including public transport and lower-ranking road network, especially for urban deployment of cooperative services (e.g. distribution of in-vehicle information of traffic lights).

Annex 3: Overview of other relevant C-ITS literature

This annex provides an overview of additional reading material on C-ITS.

- The Data Strategy for Europe
- Declaration of Amsterdam
- Study on the Deployment of C-ITS in Europe
- ITS Directive 2010/40/EU
- Policy framework for utilisation - A pillar of better accessibility
- POLIS position paper - Cooperative systems in urban mobility
- POLIS - European cities' perspective on cooperative junctions
- Amsterdam Group - Roadmap between automotive industry and infrastructure organisations on initial deployment of Cooperative ITS in Europe
- ERTRAC - Automated Driving Roadmap (2015)
- Digital Single Market
- The Energy Union Strategy
- European Strategy for Low Emission Mobility
- Digitising European Industry Strategy
- The Directive on security of network and information systems (NIS Directive)
- Directive on privacy and electronic communications
- General Data Protection Regulation
- Opinion 03/2017 on processing personal data in the context of Cooperative Intelligent Transport Systems (C-ITS)
- Working Paper over connected vehicles (IWGDPT)
- Regulation on approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles

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