Interoperability requirements for C-ITS services with infrastructure involvement

Deliverable 1 of sub-activity 4.4
(Cooperative ITS Services Deployment Support)

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Authors

Name	Organisation
Sandro Berndt	BASt
Holger Drees	BASt
Torsten Geissler	BASt
Ludovic Simon	CEREMA
Claudio Gombi	SINA
Ilkka Kotilainen	FTA
Mikko Tarkiainen	VTT
Eetu Pilli-Sihvola	TRAFI
Johnny Svedlund	STA
Clas Roberg	STA
Onno Tool	RWS
Susanne Schulz	Hessen Mobil
Ulrich Haspel	ABD Südbayern
Paul Wadsworth	Capita
Fabrizio Paoletti	Autostrade Tech
Lina Gaviria Orjuela	DGT
Anders Bak Sørensen	DRD

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Glossary

Abbreviation	Explanation
ASECAP	European Association of Operators of Toll Road Infrastructures
BSP	Basic System Profile
C2C-CC	Car-to-Car Communication Consortium
CAM	Cooperative Awareness Message
CCAM	Cooperative, Connected and Automated Mobility
CEDR	Conference of European Directors of Roads
CEF	Connecting Europe Facility
CEN	European Committee for Standardization
C-ITS	Cooperative Intelligent Transport Systems
DENM	Decentralized Environmental Notification Message
DG	Deployment Guideline
EC	European Commission
EIP	European ITS Platform (2013-02/2015)
EIP+	European ITS Platform+ (2014-2015)
EU EIP	EU ITS Platform (2016-2020)
ETSI	European Telecommunication Standards Institute
EU	European Union
GDP	Gross Domestic Product
GLOSA	Green Light Optimal Speed Advisory
I2I	Infrastructure-to-Infrastructure Communication
I2V	Infrastructure-to-Vehicle Communication
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITS G5	European profile standard for communications in the 5 GHz band (based on IEEE standard 802.11/802.11p)
IVS/IVI	In Vehicle Signage / In Vehicle Information
LoS	Level of Service
OHLN	Other Hazardous Location Notification
PKI	Public Key Infrastructure
POLIS	European Cities and Regions Networking for Innovative Transport Solutions
PVD	Probe Vehicle Data
RTTI	Real Time Traffic Information
RWW	Road Works Warning
SPAT-MAP	Signal Phase and Time and Map Data
SRTI	Safety Related Traffic Information
TCC	Traffic Control Center
TEN-T	Trans-European Network - Transport
V2I	Vehicle-to-Infrastructure Communication

TABLE OF CONTENTS

Document Information 2

Glossary 3

1. Introduction 6

1.1. Context 6

1.2. EU EIP role in the C-ITS services deployment preparation 10

2. C-ITS services deployment preparation – State-of-play 12

2.1. Conceptual basis 12

2.2. State-of-play 14

3. Knowledge Base 17

3.1. Relevant Standards – Overview 17

3.2. Amsterdam Group White Papers 18

3.3. Specifications developed by C-ITS pilots and deployment initiatives 22

3.3.1. SCOOP@F 22

3.3.2. ECo-AT 25

3.3.3. Shared Document List and Harmonised C-ITS Corridor Profile 29

4. Profiling issues **31**

4.1. Interoperability challenge 31

4.2. Profiling sunflower 32

5. Common Requirements Engineering **34**

5.1. Intended collaboration 34

5.2. Process 35

6. Outlook **37**

7. References **38**

1. Introduction

1.1. Context

Intelligent Transport Systems (ITS) and core European ITS services are a major goal of collaboration among European road authorities and road operators. In the context of strategic programs they have served as an important and powerful tool to improve safety, to battle congestion and to reduce environmental pollution. As an example, the impacts of the initiative Congestion Free Hessen are briefly illustrated below (see Figure 1). Congestion Free Hessen is paramount to a bundle of ITS measures, such as (trans-) regional traffic management, temporary use of hard shoulder, road works slot management, each of them contributing to meet the typical goal set of road authorities and operators. In sum, the bundles of measures have led to remarkable impacts in terms of reduction of heavy damage accidents by 30%, travel time reduction up to 20%, temporary increase of road capacity of up to 25% and reduction of total congestion time by 80% within a decade [Schulz 2016].

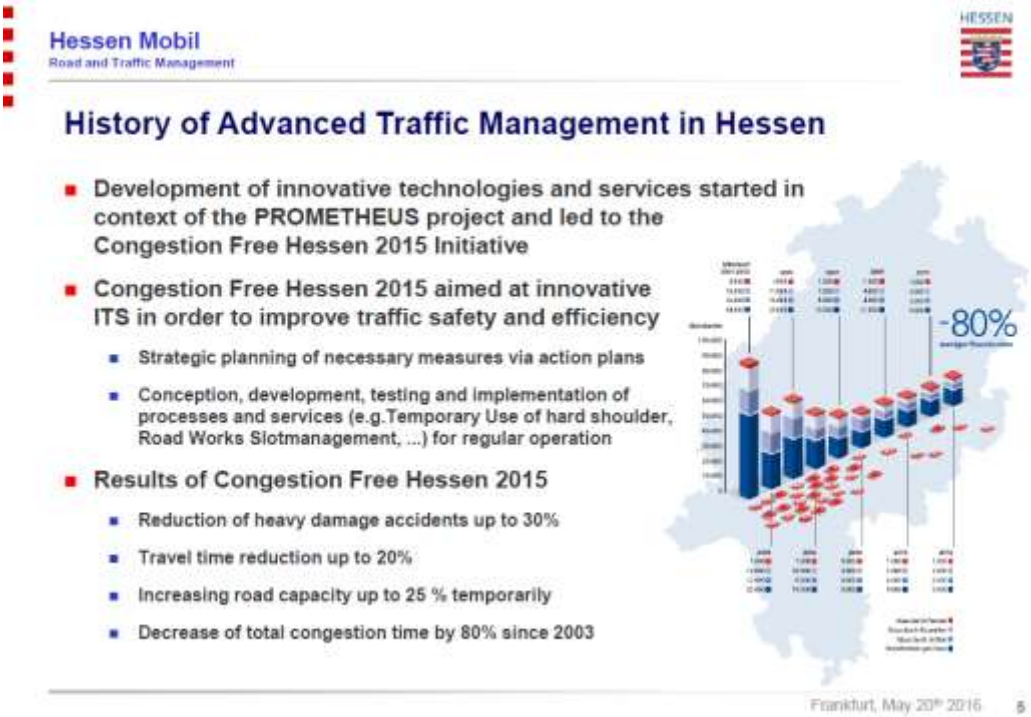


Figure 1 : Summary Impact of ITS measures (example: Congestion Free Hessen)

The measures have provided their contribution to release the burden of mobility to road users. However, as transport demand is closely linked to socio-demographic indicators such as Gross Domestic Product (GDP), it does not surprise that flourishing regions constantly face issues with mobility provision. Other contributing factors comprise, but are not limited to, an ageing society with persons remaining in the workforce longer and pursuing an active and mobile lifestyle even in retirement. Freight and logistics services are also growing due to the globalised markets and transport needs, home delivery of online ordered goods, and zero-stock concepts with just in time delivery.

On to supply side, Information and Communication Technologies (ICT) have offered the potential to digitise and connect basically all spheres of our lives. When in previous years IT has been used to make the processes within specific domains intelligent (be this domain either vehicles or roads or ...), the focus is now on connecting different domains or industries (see Figure 2). When connectivity and communication become increasingly ubiquitous factors, the borders between “verticals” become blurred by “horizontals” such as Internet of Things (IoT). This leads also to convergence of industries and markets and with that also to reshaping roles and responsibilities as well as business models.

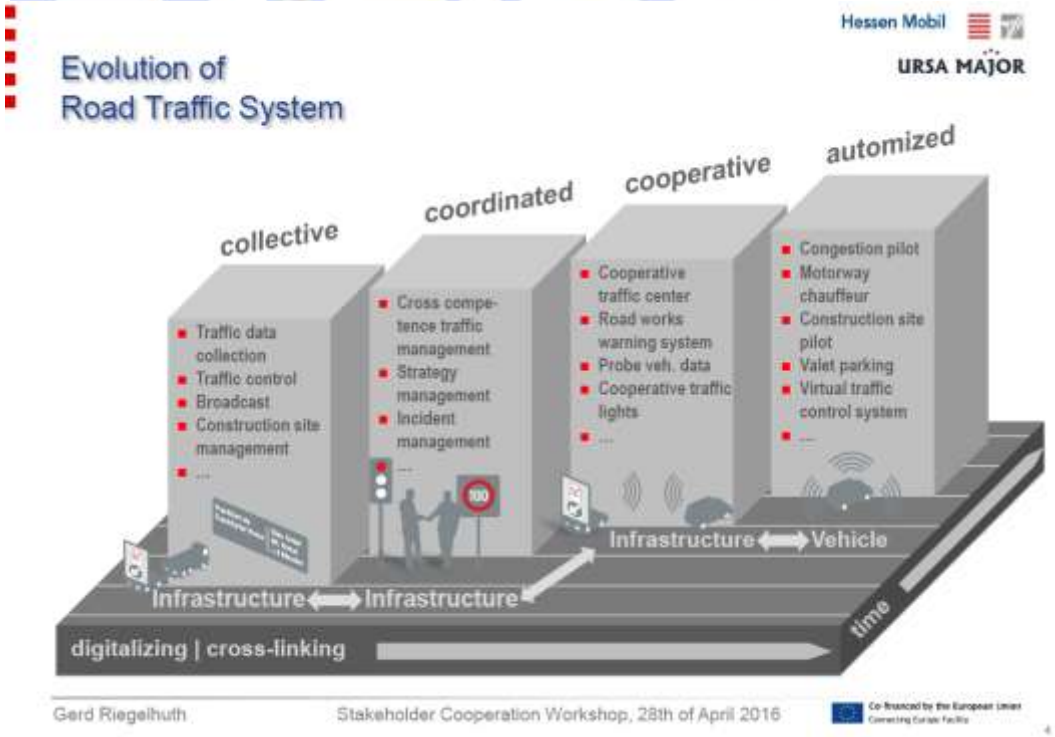


Figure 2 : Evolution of Road Traffic System (ex.: Hessen Mobil) [Riegelhuth 2016]

Cooperative ITS (C-ITS) services represent a new service generation. Typical services for the initial deployment phase are illustrated in the list of Day One and Day 1.5 services (see Figure 3). This list aggregates the implementers' plans in Europe, and this list is agreed among all stakeholders contributing to the C-ITS Platform [C-ITS Platform 2016].

#	Day 1 Services	#	Day 1.5 Services
1	Emergency electronic brake light	1	Off street parking information
2	Emergency vehicle approaching	2	On street parking information and management
3	Slow or stationary vehicle(s)	3	Park & Ride information
4	Traffic jam ahead warning	4	Information on AFV fuelling & charging stations
5	Hazardous location notification	5	Traffic information and smart routing
6	Road works warning	6	Zone access control for urban areas
7	Weather conditions	7	Loading zone management
8	In-vehicle signage	8	Vulnerable road user protection (pedestrians and cyclists)
9	In-vehicle speed limits	9	Cooperative collision risk warning
10	Probe vehicle data	10	Motorcycle approaching indication
11	Shockwave damping	11	Wrong way driving
12	GLOSA / Time To Green (TTG)		
13	Signal violation/Intersection safety		
14	Traffic signal priority request by designated vehicles		

Figure 3 : Agreed Day One / Day 1.5 C-ITS services [C-ITS Platform 2016]

It becomes visible that some of services are not new (e.g. Hazardous location notification, Road Works Warning, Weather conditions) but connectivity between all types of ITS stations (vehicles, roadside, center, personal, see also Figure 4) makes it increasingly possible to access data in (near) real time and subsequently provide services with a higher quality. The EIP+ C-ITS White Paper [Berndt et al. 2016] has illustrated potential Level of Service (LoS) improvement for selected services, representing Safety Related Traffic Information (SRTI) or Real Time Traffic Information (RTTI), see Commission Delegated Regulations (EU) No 886/2013 and 2015/962. At the same time, it becomes obvious that access to (near) real time incident data enables a variety of new services which have not been feasible without cross-domain connectivity.

Several policy documents aim at deploying C-ITS services by the year 2019 in a coordinated way, e.g. EC C-ITS Strategy (COM (2016) 766 final) [C-ITS Strategy 2016], with references to the Declaration of Amsterdam on cooperation in the field of Connected and Automated Driving [DoA 2016] and deployment plans of the automotive industry [C2C-CC 2015]. It requires strong collaboration on various layers (policy making for legal certainty, successful performance of planned pilots and deployment initiatives, supportive actions on expert level and auxiliary topics (such as spectrum and frequency) for a coordinated deployment of C-ITS services. Interoperability marks one of the challenges and is discussed further below in this report.

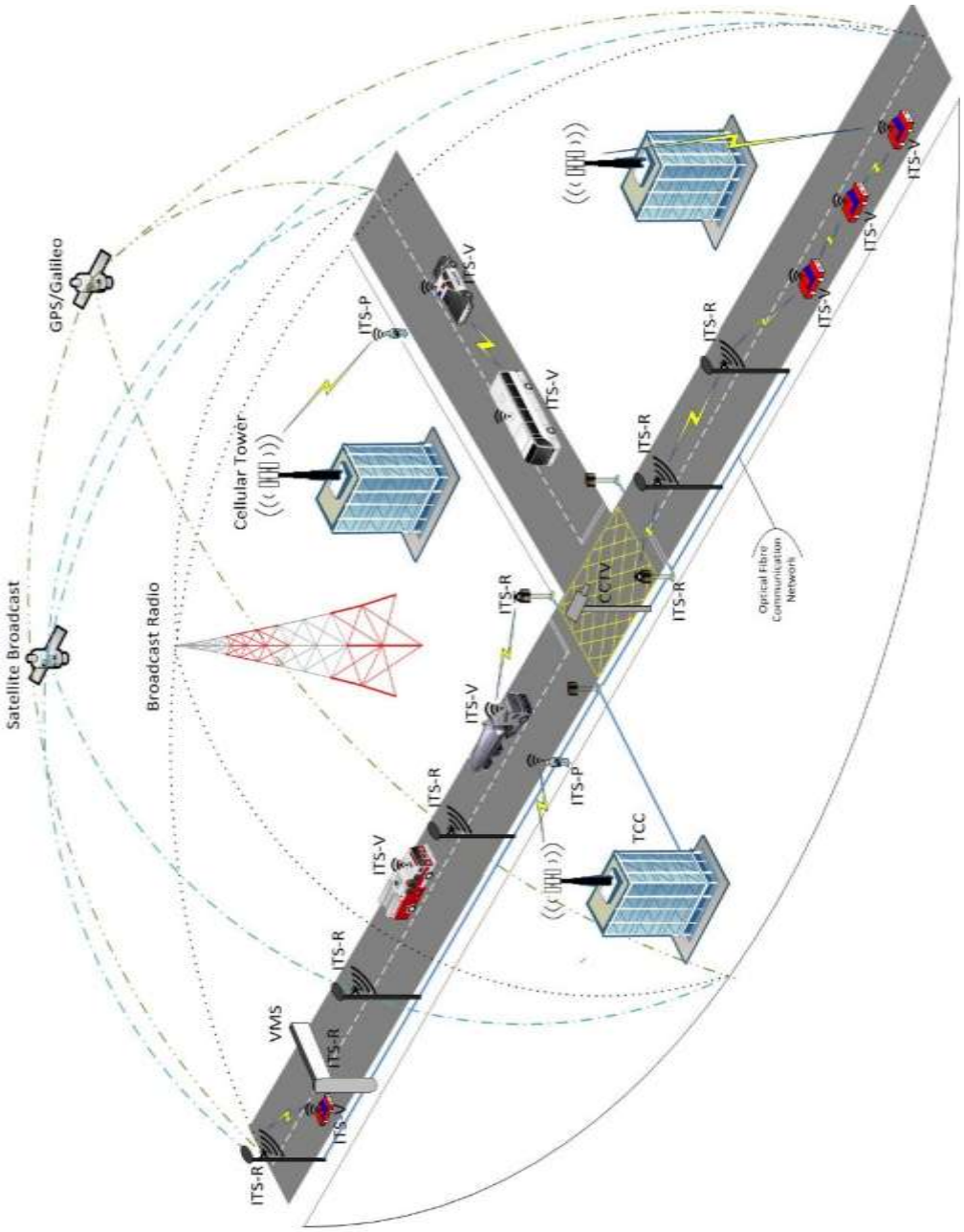


Figure 4 : Connectivity between ITS stations in a Concept Hybrid Communication Solution

1.2. EU EIP role in the C-ITS services deployment preparation

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 authorities and 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 is among others (i.e. C-Roads Platform, further discussed below) in a privileged position (see Figure 5) to lay the basis for a large scale uptake of C-ITS across the TEN-T network in Europe by providing advice to the following addressees (see also [Geissler et al. 2016]):

- to the National road authorities and road operators partnering in the European ITS Platform (EU EIP) community as institutions becoming increasingly engaged in initial deployment initiatives,
- to the European Commission in their roles as funding and regulatory institution and organiser of the Cooperative ITS Platform and
- to relevant stakeholders and multi-stakeholder collaborations engaged in preparing C-ITS deployment such as the Amsterdam Group and the umbrella organisations represented therein (CEDR, ASECAP, POLIS, Car2Car Communication Consortium).

Figure 5 : EU EIP C-ITS Activity supporting C-ITS deployment, adapted from [Geissler 2016]

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.

The content of this Deliverable stems from the first task on functional interoperability. It comprises the following elements:

- Good/best practise from pilot initiatives concerning the deployment of C-ITS services with infrastructure involvement (I2V/V2I),
- Interoperability requirements of road authorities and road operators for services with infrastructure involvement,
- Requirements on data exchange interfaces in the responsibility of road authorities and operators to DATEX II related activities and initiatives,
- Liaison with CODECS (Horizon 2020 CSA) on functional specifications, protocols, message sets and triggering conditions.

It becomes clear from the assessment of the current state of C-ITS deployment preparation that EU EIP can serve as a contributor at large for functional interoperability while C-Roads is seen as the driving force for large scale implementation of interoperable C-ITS services in Europe. This Deliverable is organised in the following way:

- Chapter 2 assesses the current state-of-play concerning pilot deployment of C-ITS services.
- Chapter 3 describes the knowledge base concerning functional interoperability, including an overview of relevant standards, White Papers developed by the Amsterdam Group and specifications developed by C-ITS pilots and deployment initiatives.
- Chapter 4 highlights issues on profiling such as the interoperability challenge and the fact that one Basic System Profile on vehicle side has got many counterparts on infrastructure which implies the need for a harmonised infrastructure profile.
- Chapter 5 elaborates on the common requirements engineering.

The released document (v1.0) has to be characterised as draft status. It is foreseen that platform external comments are leading to a final version in the year 2018.

2. C-ITS services deployment preparation – State-of-play

2.1. Conceptual basis

The deployment of C-ITS services need the collaboration of many stakeholders in an ecosystem. Some years ago an organisational architecture has been established which provides the framework for all activities concerning C-ITS deployment and operation (CEN/ISO TS 17427). The concept of top level roles (Policy Framework, System Management, Service Operation, Using the System) that can be broken down to sub-roles is illustrated in Figure 6. As an example, potential sub-roles in system management comprise the management of the service catalogue, change processes, tests, compliance assessment, homologation processes and service levels [Herb 2013]. It becomes clear that service operation represents only part of the overall C-ITS system which involves also several common elements (dedicated to security, privacy, compliance assessment etc.).

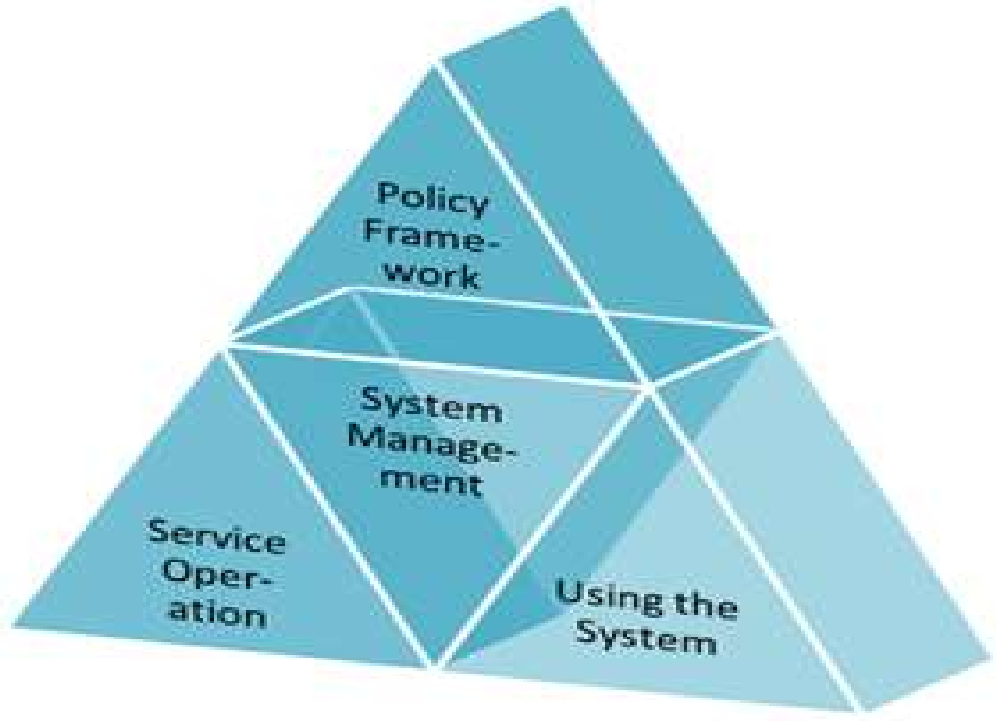


Figure 6 : Top level roles according to organisational architecture (CEN/ISO TS 17427) [Herb 2013]

From a more business model point of view, the different roles can be named as follows from the Final Report of the C-ITS Platform Phase II [C-ITS Platform 2017], Annex II on business models. There are producers of data/information, who should somehow be rewarded. There are consumers, who should somehow pay for their usage. There are sponsors who want some information to be subsidised or free. The sponsors will also have to inject the start-up investment until the system is big and rich enough of valuable data to be self-sustaining. There are enablers who set up the system, keep it running and handle rights to data and payments. There are enrichers who aggregate data to information and knowledge on a higher level. Policies and rules for the system make it possible to handle different jurisdictions and sponsorship setups which likely results in a federated network (see Figure 7 and Figure 8).

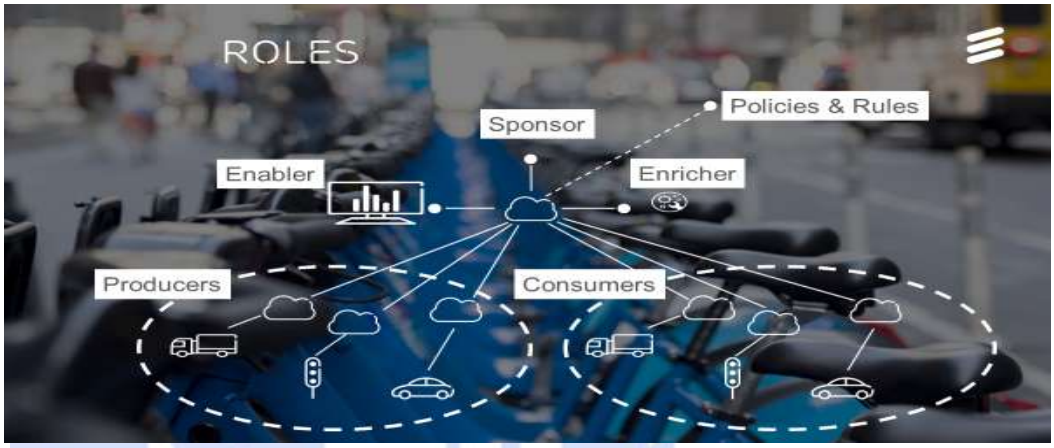


Figure 7 : Example illustration of roles in the C-ITS ecosystem [C-ITS Platform 2017]

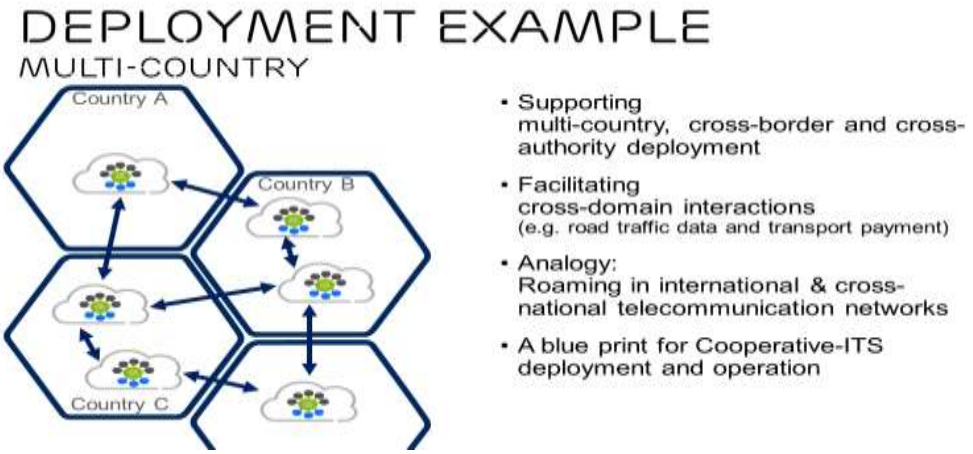


Figure 8 : Conceptual example for multi-country deployment [C-ITS Platform 2017]

2.2. State-of-play

The European Commission promotes the steps towards C-ITS Deployment which are EC-steered in an illustrative way as follows (see Figure 9):

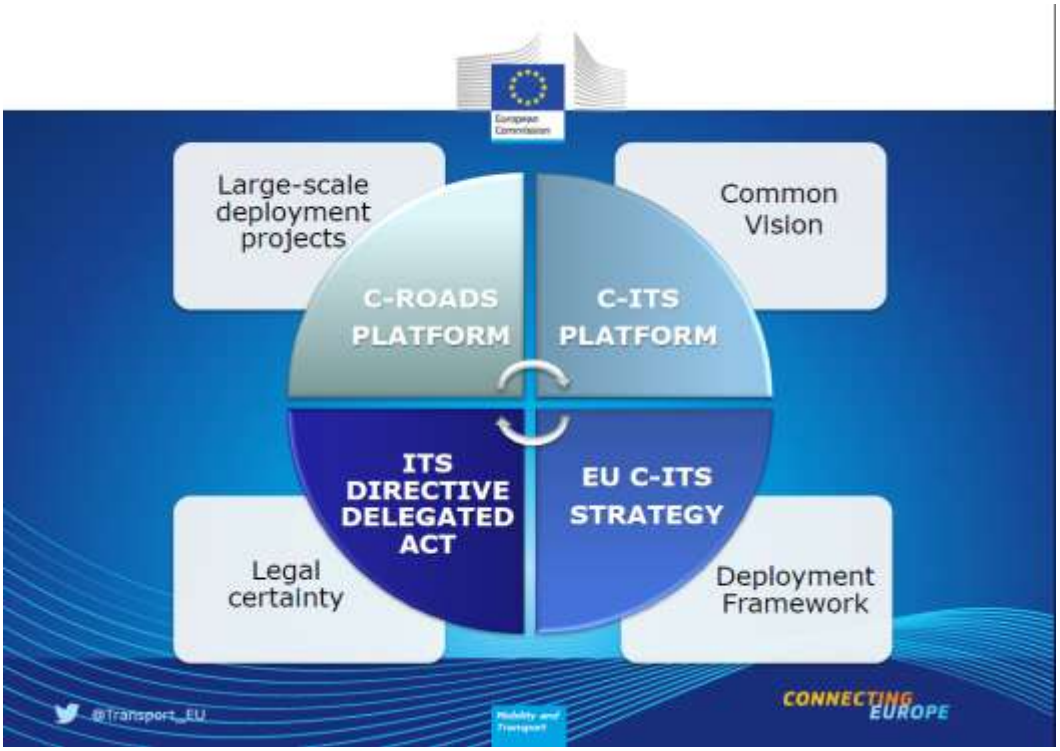


Figure 9 : Integrated elements of C-ITS deployment preparation on EU level [EC 2016]

European ITS Platform

- The European Commission has worked intensely with all C-ITS stakeholders to establish a common vision and framework for C-ITS Deployment in Europe. The work in the C-ITS Platform, initiated in 2014, has led to many recommendations which are laid down in the Final Report of the first phase of the C-ITS Platform [C-ITS Platform 2016].
- Subsequently in its second phase, the C-ITS Platform has taken on board also issues on advancing towards automated driving, e.g. Digital and Physical Infrastructure needs, Extended Traffic Management and the role of automation in urban areas. The C-ITS Platform has released its Final Report of the second phase in September 2017 [C-ITS Platform 2017].

- EC has taken up the results and has formed a European strategy for C-ITS as “a milestone towards cooperative, connected and automated mobility”. The strategy has been published in November 2016 [EC 2016]. EC has identified several issues to be tackled on EU level, such as priorities for deployment (Day One services), security of C-ITS communication, privacy and data protection safeguards, communication technologies and frequencies, interoperability at all levels (infrastructure, data, services, application and networks), compliance assessment, legal framework, and international cooperation.
- The cross-cutting nature of some of the EU level issues (e.g. security, privacy, compliance assessment) requires establishing legal certainty as a precondition to large scale investment in deployment by core actors. Hence, EC has embarked with Member States on a process of developing several Delegated Acts on C-ITS under an extended mandate of the ITS Directive 2010/40/EU (COM (2017) 136 final [ITS Directive extension 2017]). After a scoping exercise in May 2016, the sequence of Member States Expert Meeting towards specifications for Cooperative Intelligent Transport Systems is continued in autumn 2017.
- As the success of policy is indicated and proven by successful implementations, EC is highly interested in a powerful and dedicated tool to steer the large scale C-ITS pilot deployment in various Member States. This provides the C-Roads Platform with a prominent role in C-ITS deployment in Europe. These ambitions are also underlined by Commissioner Bulc kicking off C-Roads personally in December 2016 (see Figure 10).
- Initially, C-Roads has encompassed eight Member States as Core Members (Austria, Belgium (Flanders), Czech Republic, France, Germany, Netherlands, Slovenia, UK), with several associate members in Europe (Finland, Ireland, Hungary, Switzerland), and in addition, Australia and New Zealand.
- On the basis of the CEF Call 2016 Transport results, pilots in another eight European states (Finland, Sweden, Denmark, Norway, Italy, Spain, Portugal, Hungary, also Belgium (Wallonia)) will be continued or ramped up by late 2017. The expectation towards end of 2017 is therefore that the number of C-Roads Core Members will be doubled.
- In terms of EU statistical indicators provided by Eurostat, C-ITS services based on C-Roads would then be able to cover – on the basis of future nationwide service roll-out – 82% of the EU-28 population.

Figure 10 : C-Roads Signing Ceremony with Commissioner Bulc, INEA Director Beckers and Ministry representatives of C-Roads Core Members [Boehm 2017]

European ITS Platform

3. Knowledge Base

3.1. Relevant Standards – Overview

As standards represent an important prerequisite for deployment, the European Commission issued a mandate [Mandate M/453, 2008] asking the European Standardisation Organisations to provide a minimum set of standards required for deployment of C-ITS. CEN/ISO and ETSI agreed on a work split where CEN/ISO has concentrated on framework architecture and road infrastructure related topics whereas ETSI has focused on various communication aspects including protocols and security as well as V2V applications [Herb et al. 2013]. In responding to the European mandate M/453 for developing standards for C-ITS [CEN ETSI 2013], CEN and ETSI have announced the first release of standards in the beginning of 2014 [ETSI 2014]. This has marked an important point for moving ahead towards deployment.

The C-ITS Platform in its first phase [C-ITS Platform 2016] has stressed the importance of standards by establishing a dedicated Working Group on standardisation. Since the topic as such has been horizontal by nature, it has turned out to be an exercise of different Working Groups (e.g. on security, technical aspects, implementation aspects and international cooperation). The identified key items have pointed to different needs:

- Elaboration of test standards,
- Profiling of standards to ensure interoperability in implementation,
- Proper maintenance of standards due to implementation needs.

In addressing the needs, a first step has been taken on platform level to provide an overview of the standards that are used by the different C-ITS pilots and deployment initiatives in Europe:

- The overview has been produced as an Excel table (Annex 7) listing per pilot / deployment initiative the standards and the application to different use cases. Figure 11 provides a snapshot of the Excel file.
- The focus of the exercise has led on the near term. It has been therefore appropriate to concentrate the exercise on the initial phase of C-ITS deployment. This explains the adherence to the list of Day 1 services (see Figure 3).
- The goal has been to provide a snapshot of the state-of-play by end of 2015 in order to identify which standards are relevant for interoperability of C-ITS services on European level.
- Profiling of standards and elaboration of test standards has not yet been the main target of the exercise at that point in time.

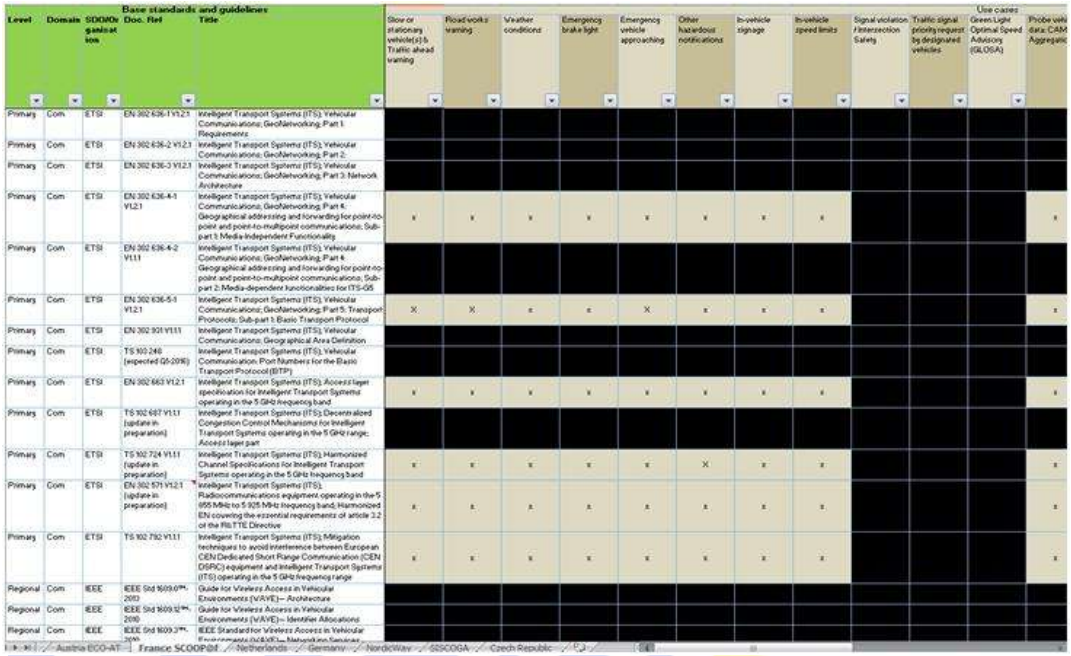


Figure 11 : Overview of applied standards in preparing C-ITS deployment [C-ITS Platform 2016]

3.2. Amsterdam Group White Papers

The Amsterdam Group as a strategic alliance of committed stakeholders from infrastructure organisations (CEDR, ASECAP, POLIS) and the automotive industry (C2C-CC) for C-ITS deployment has elaborated based on its 2013 roadmap for the initial phase of deployment [Amsterdam Group 2013] on a set of White Papers:

- The White Papers have been produced with the intention to ensure interoperability of C-ITS services on the Trans-European Road Network (TEN-T).
- The scope of the White Papers lies in Day 1 services with infrastructure involvement. Based on the roadmap these I2V/V2I services comprise Road Works Warning, In-Vehicle Signage/Information (IVS/IVI), Signal Phase and Time and Map Data (SPAT-MAP) as well Probe Vehicle Data (PVD) for improving traffic management.
- The White Papers can be perceived as a first exercise for profiling the relevant standards and in doing so providing guidance for the deployment initiatives. The White Papers can also be regarded as providing feedback towards and further input to standardisation.

The Amsterdam Group has published a set of White Papers in April 2016 (Figure 12). The publication has been promoted in the workshop C-ITS deployment is underway, jointly organised by Amsterdam Group and CODECS. The results are published as CODECS Deliverable D2.1 [Berndt Geissler 2016].

The set of White Papers consists of four documents addressing services in different Operating Environments: In-Vehicle Signage/Information (IVS/IVI), Signal Phase and Time and Map Data (SPAT-MAP) and Road Works Warning (RWW). RWW as being the most mature service across pilots and deployment initiatives is addressed with two documents. The documents comprise a functional description as well as the message set and the relevant triggering conditions. The current version concentrates on short term road works. The reproduction of Long Term Road Works Warning (LT-RWW) is planned for a further document release. Incorporating LT-RWW has turned out to be a challenging issue since a combination of messages (DENM, IVI, MAP), maintained by different standardisation bodies, has turned out to be the most promising way forward. A follow-up of the 2016 workshop on this topic is organised in the context of the CODECS Support Action in October 2017.

Exemplary illustrative content of the RWW document on message set and triggering conditions is reproduced in Figure 13, Figure 14 and Figure 15. The scope of the IVS/IVI White Paper is illustrated in Figure 16.

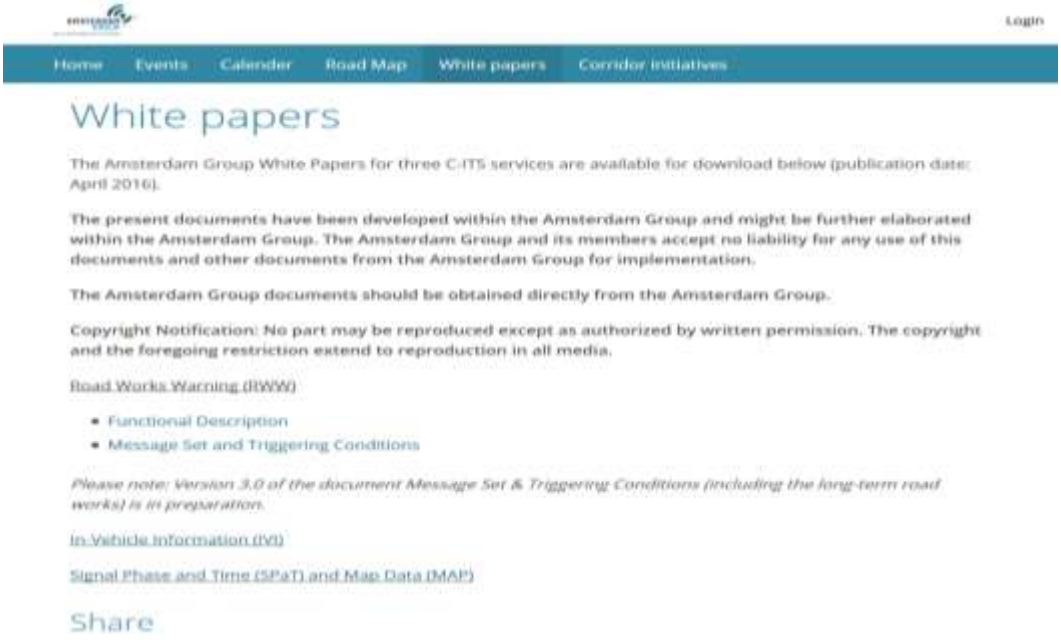


Figure 12 : Amsterdam Group White Papers on Amsterdam Group Website (www.amsterdamgroup.eu) [Amsterdam Group 2016]

	start sending DENM	update DENM	stop sending DENM
stand-alone mode of short-term road works	... is triggered by: - signboard of RWST is opened or attenuator (TMA) is lowered - pre-warner is activated → DENM is sent as soon as sign board is visible or flashers are on. Alternatively the stand-alone mode is started when the system is in basic service mode and connection to the traffic control centre is lost for a pre-defined time interval.	... is triggered by: - change of position[1] - change of arrow sign configuration → DENM is updated when content changes ... is triggered by: (validityDuration – (currentTime – detectionTime) < 10 sec)	... is triggered by: - signboard of RWST is closed or attenuator (TMA) is lifted - pre-warner is de-activated → DENM is no longer sent as soon as sign board is no longer visible / flashers are off Alternatively the stand-alone mode is stopped and basic service mode is started when the RWST is connected to the traffic control centre and receives enhanced information
basic service mode of short-term road works	... is triggered by: - connection established between RWST and traffic control centre → DENM is sent as soon as enhanced information from the traffic control centre is available.	... is triggered by: - change of position1 - change of arrow sign configuration - updated information from the traffic control centre → DENM is updated when content changes ... is triggered by: validityDuration/2 < (CurrentTime-detectionTime)	... is triggered by: - signboard of RWST is closed or attenuator (TMA) is lifted - pre-warner / MRS is de-activated → DENM is no longer sent as soon as sign board is no longer visible / flashers are off Alternatively the basic service mode is stopped and stand-alone mode is started when the connection to the traffic control centre is lost for a pre-defined time interval.
stationary long-term	*Triggering conditions for long-tem road works will be included in the 2nd release of the document "Message Set and Triggering Conditions for Road Works Warning Service".*		

Figure 13 : Triggering conditions for Road Works Warning [AG White Paper 2016]

European ITS Platform

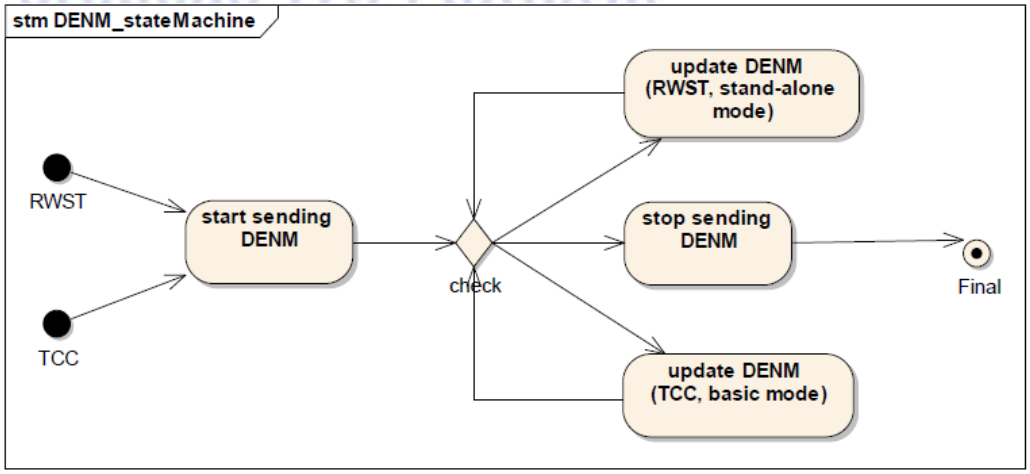


Figure 14 : State machine visualising description of Fig 13 [AG White Paper 2016]

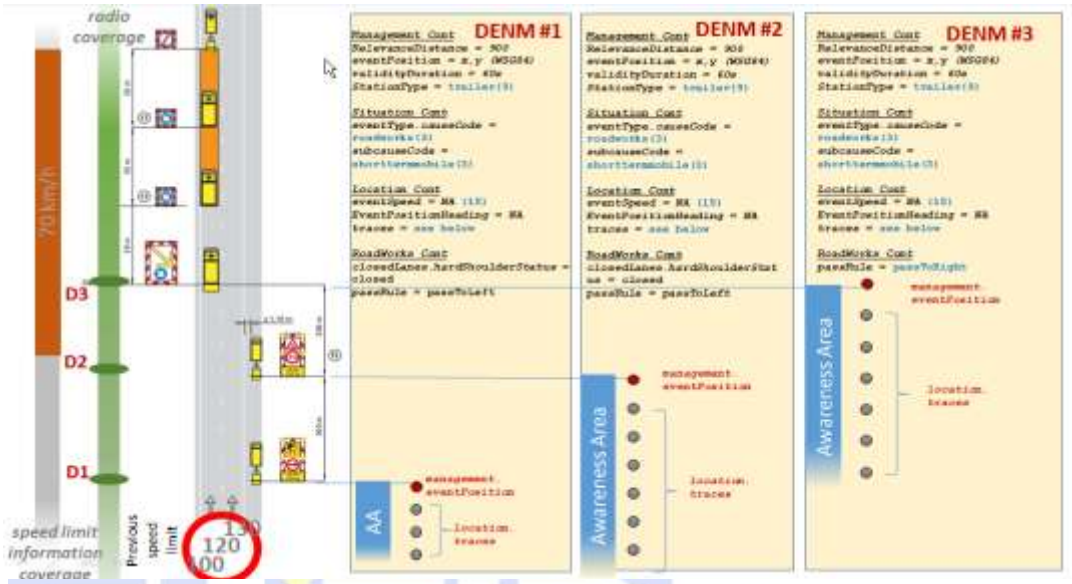


Figure 15 : Example set-up for short term mobile road works, stand-alone mode, trailer and pre-warner equipped [AG White Paper 2016]

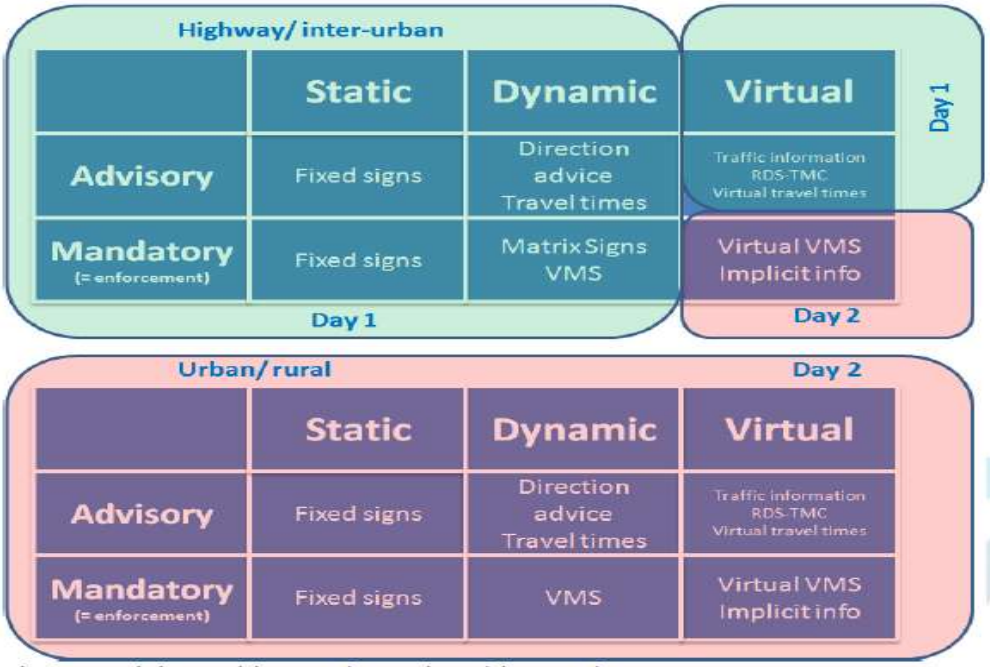


Figure 16 : Scope of IVS/IVI White Paper [AG White Paper 2016]

3.3. Specifications developed by C-ITS pilots and deployment initiatives

In the past four years, a significant number of C-ITS pilots and deployment initiatives has been formed in order to kick start C-ITS deployment all over Europe. This comprises, amongst others, SCOOP@F, C-ITS Corridor (NL-DE-AT), NordicWay, InterCor and all C-Roads pilots (see chapters 4 and 5 more specifically for the role of C-Roads). A previous report of the EU EIP community (EIP+ C-ITS White Paper [Berndt et al. 2016]) has produced an inventory of the initiatives with respect to the status end of 2015.

In a certain moment, all the initiatives have come up with a set of specifications, following the release schedule of the initiative. In the following, specifications developed by national as well cross-national initiatives are described below on an example basis. An example for the scope of the specifications, taken from ECo-AT, is copied in below.

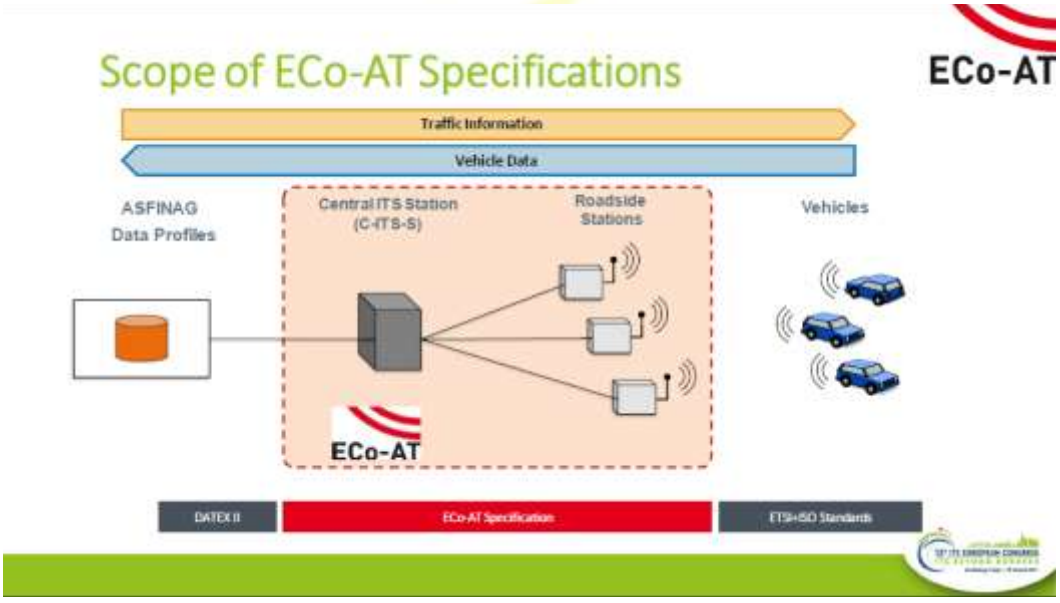


Figure 17 : Scope of C-ITS specifications, example ECo-AT [Molin Harrer 2017]

3.3.1. SCOOP@F

The first pilot for C-ITS deployment in France is organised via the project SCOOP@F. Already started already back in 2014, the project is now in its second phase (2016-2018). The five pilot sites in France cover Ile-de-France, the motorway between Paris and Strasbourg, Isère, the Bordeaux ring road and Bretagne. Those pilot sites comprise a very different mix of road types and operating environments, involving motorways, major arterial roads in conurbations, bi-directional interurban and local roads.

The deployment involves a fleet of 3,000 vehicles and approximately 2,000 km of roads. The services focus on improving road user and road operator safety (data collection, road works warning, hazardous location notification). SCOOP@F and its “son projects”, i.e. French part of InterCor and C-Roads France, contribute to the French catalogue of C-ITS services [Ollinger 2017], see Figure 18.

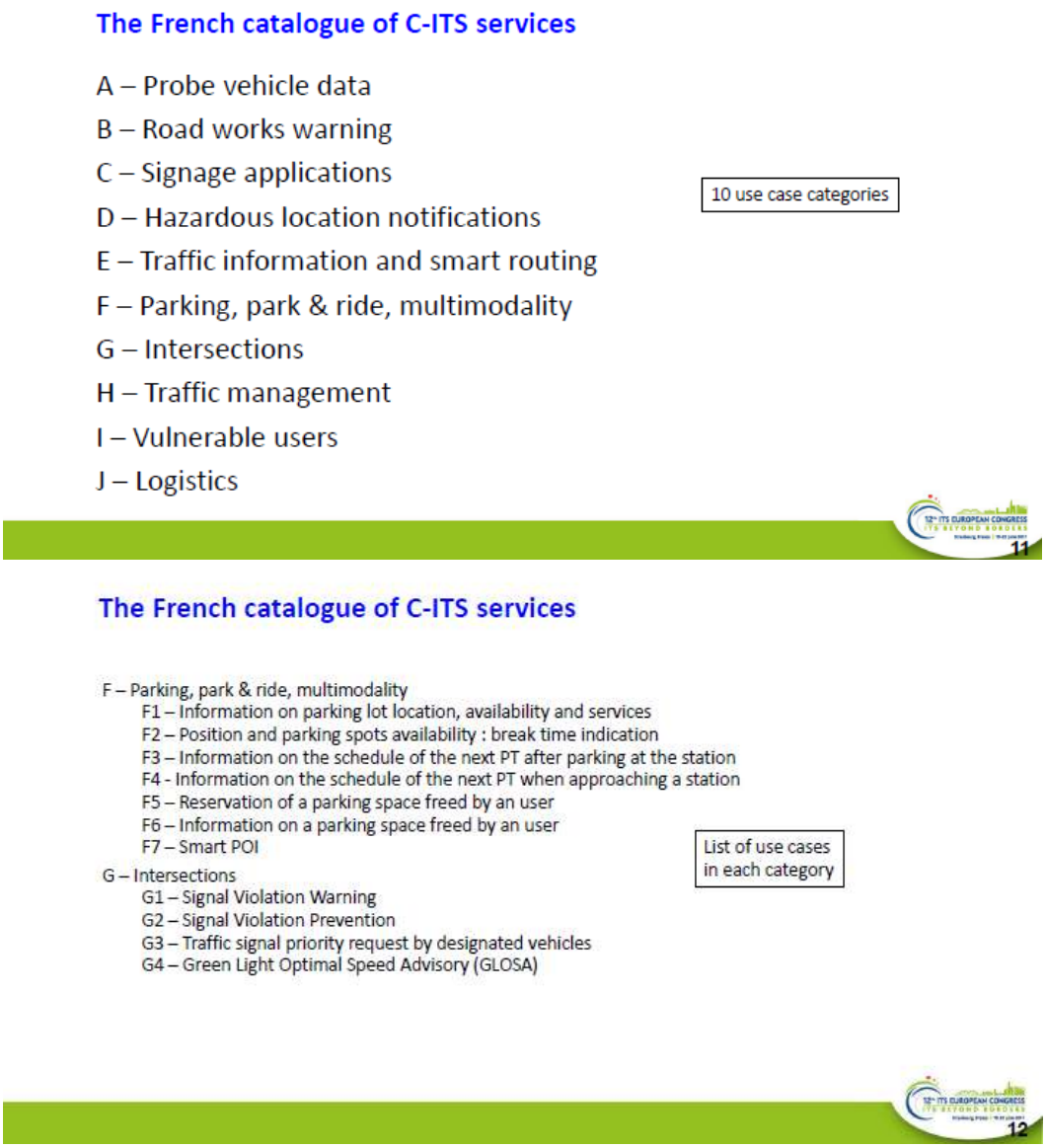


Figure 18 : French catalogue of C-ITS services [Ollinger 2017]

SCOOP@F has published a document set in two releases, the first one in autumn 2015, the second one in summer 2017. The releases are available on the website (http://www.scoop.developpement-durable.gouv.fr/). Figure 20 provides an overview of the document set and a mapping of changes to the first release. The document reference Esposito 2017] also contains an excerpt of the detailed update and change explanations.

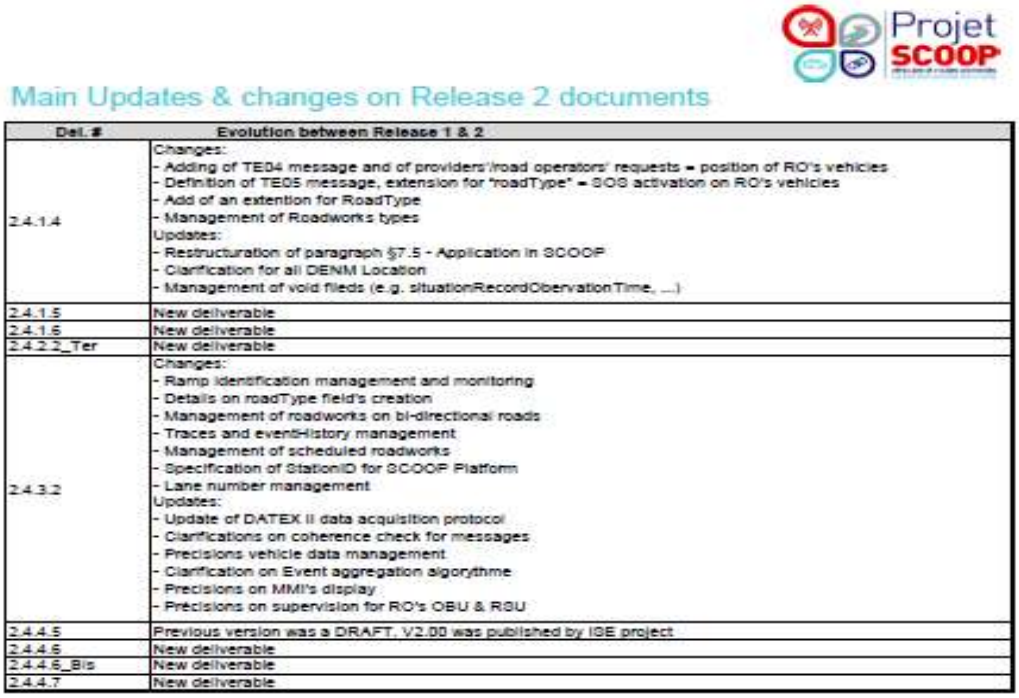
SCOOP Releases Monitoring
Main updates & changes

Document > SCOOP Release Monitoring
Date > 12/05/2017
Responsible > Marie-Christine ESPOSITO, MEEM
Version > V1.0

Del. #	Name	Rel. 1 18/10/16	Rel. 2 12/06/17	Rel. 2_Patch 9/8/17	Comments
2.4.1	Common set of functional and technical specifications	1.0	2.00	2.00	See details
2.4.1_Bis	List of standards	1.2	2.00	2.00	Patch > See details
2.4.1_appendix 1	Renewal of PC & Upload of LOGS	4.1	2.00	2.00	See details
2.4.1.2	Specifications of DENM fields	1.0	2.00	2.00	See details
2.4.1.3	LOGs specification	1.0	-	-	Currently beeing updated. See release 3
2.4.1.4	Specification of DATEX II-2.3 messages	1.0	2.00	2.00	See details
2.4.1.5	Network architecture for road operators	-	2.00	2.00	New del.
2.4.1.6	IPv6 addressing over G5	-	2.00	2.00	New del.
2.4.2.1	RSU specification	3.1	-	-	Currently beeing updated. See release 3
2.4.2.2	OBU specification for road operators	3.0	-	-	Currently beeing updated. See release 3
2.4.2.2_Bis	SW OBU specification for road operators	1.0	-	-	Currently beeing updated. See release 3
2.4.2.2_Ter	Management of displays on the MMIs of road operator OBUs	-	2.00	2.00	New del.
2.4.3.1	General specifications of SCOOP platform	1.0	x	x	Del. superseded by del. 2.4.3.2
2.4.3.2	Detailed functional specifications of SCOOP platform	1.0	2.00	2.00	See details
2.4.4.1	Analysis of safety objectives	4.0	1.00	1.00	Same version but new version number administation
2.4.4.2	Security Risk analysis	2.0	-	-	Currently beeing updated. See release 3
2.4.4.2_Bis	Security Risk analysis - Appendix	-	-	-	Currently beeing updated. See release 3
2.4.4.3	Comparison between the risk analysis performed by Solucom and [...] in [...] 102 893	2.0	-	-	Currently beeing updated. See release 3
2.4.4.4	State of the art of public key infrastructures for cooperative ITS	-	2.00	2.00	New del.
2.4.4.5	PKI system requirements specifications - v1.1	-	2.00	-	See details
2.4.4.6	PKI architecture and technical specifications	-	2.00	2.00	New del.
2.4.4.6_Bis	Use case scenarios with security data	-	2.00	2.00	New del.
2.4.4.7	Strategies for changing pseudonyms and sizing the PKI traffic	2.0	1.00	1.00	Same version but new version number administation
Nb del		**15**	**15**	**14**	

Release 2 link > http://www.scoop.developpement-durable.gouv.fr/en/technical-specifications-a22.html

Figure 19 : SCOOP release overview [Esposito 2017]



Main Updates & changes on Release 2 documents

Del. #	Evolution between Release 1 & 2
2.4.1.4	Changes: - Adding of TE04 message and of providers'/road operators' requests = position of RO's vehicles - Definition of TE05 message, extension for "roadType" = SOS activation on RO's vehicles - Add of an extention for RoadType - Management of Roadworks types Updates: - Restructuration of paragraph §7.5 - Application in SCOOP - Clarification for all DENM Location - Management of void fileds (e.g. situationRecordObervationTime, ...)
2.4.1.5	New deliverable
2.4.1.6	New deliverable
2.4.2.2_Ter	New deliverable
2.4.3.2	Changes: - Ramp identification management and monitoring - Details on roadType field's creation - Management of roadworks on bi-directional roads - Traces and eventHistory management - Management of scheduled roadworks - Specification of StationID for SCOOP Platform - Lane number management Updates: - Update of DATEX II data acquisition protocol - Clarifications on coherence check for messages - Precisions vehicle data management - Clarification on Event aggregation algorythme - Precisions on MMI's display - Précisions on supervision for RO's OBU & RSU
2.4.4.5	Previous version was a DRAFT. V2.00 was published by IGE project
2.4.4.6	New deliverable
2.4.4.6_Bis	New deliverable
2.4.4.7	New deliverable

Figure 20 : SCOOP release overview incl. updates and changes [Esposito 2017]

3.3.2. ECo-AT

The Austrian contribution to the C-ITS Corridor is organised in the ECo-AT project (European Corridor - Austrian testbed for Cooperative Systems), co-funded nationally by the Austrian Federal Government via the Climate and Energy fund (KliEn). ECo-AT is led by ASFINAG, Austria's national highway and expressway operator. It is split into two distinct phases, a "specification definition and testing phase" and an actual "deployment phase." In the first phase the system specifications are defined and tested in several iterative test cycles. During phase one, the work progress on the specification documents have been made publically available through a set of several releases until spring 2017, see Figure 21 for the release schedule.

Within each release, a system overview is given, the individual subsystems and component are described and the interfaces connecting them. Moreover use case descriptions and data models, e.g. DATEX II profiles, are published (see Figure 22 for exemplary overview of release content).

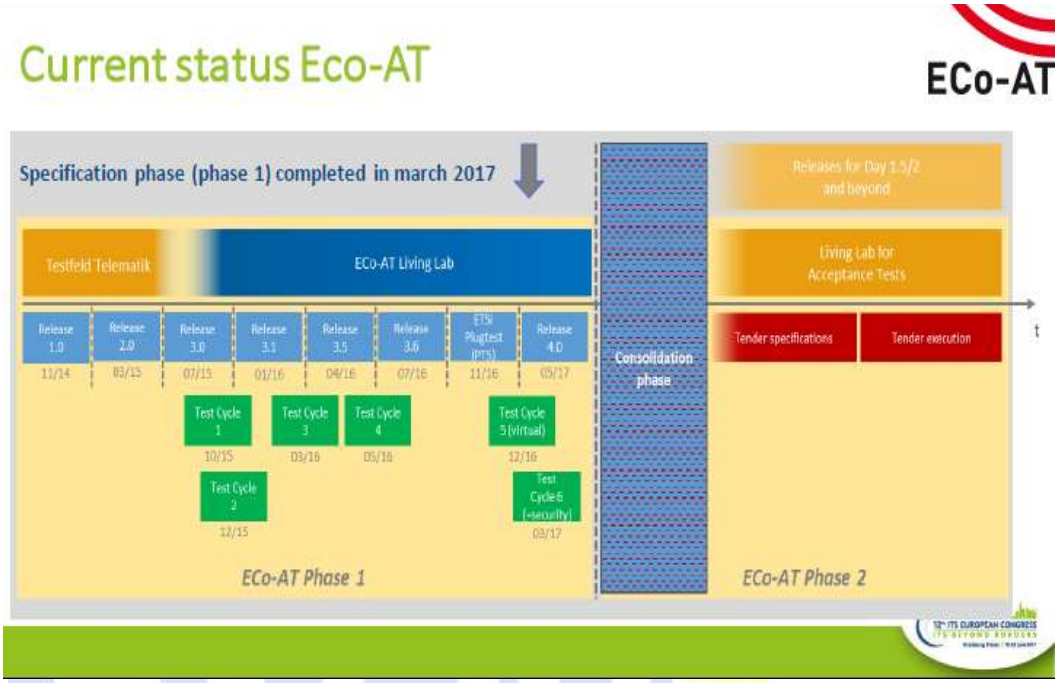


Figure 21 : ECo-AT release schedule [Molin Harrer 2017]

Figure 22 : ECo-AT release content [Molin 2017]

The specifications, available at the website www.eco-at.info, have found high interest in the community preparing for C-ITS deployment in Europe and worldwide (420 recipients by June 2017). In parallel with the finalisation of the specifications and in transition from the first to the second phase, a “Living Lab” for testing is set up by ASFINAG, which allows vendors to deploy and test roadside equipment along certain stretches of the road network and check for conformance with the system specifications. In the second phase, after verifying the results of the first phase, ASFINAG will commence with the actual deployment on the Austrian part of the corridor and further sections of the highway and expressway network from 2017 onwards.

In addition to the common use cases (i.e. Road Works Warning and Probe Vehicle Data for Improving Traffic Management) of all three C-ITS Corridor Member States [Harrer et al. 2015], ECo-AT is working on the deployment of additional Cooperative ITS services (see Figure 23) such as

- In-Vehicle Information (IVI) to inform drivers about present speed limits and provide other (hazard) information which is shown on dynamic traffic signs.
- Intersection Safety (ISS) that Cooperative Traffic Lights will provide information on the traffic lights status (SPaT – Signal Phase and Timing) and a geographical representation of the vicinity of the traffic light (in format called MAP).
- Other DENM based applications covering the information provision from the TCC to the vehicles and vice versa, one direction of information flow as a service for the road users (including various so-called „cause codes“ within the DENM messages), and the other broadening the data base for traffic managers.

	Day 1				Day 2
Use Case	Release 1	Release 2	Release 3 / 3.1	Release 3.5 / 3.6 / 4	
Road works warning (RWW) • Emergency, Short Term • Mobile RW • Long Term RW	X	X		X	
In-vehicle-information (IVI) • Dynamic signs • Static Signs	Draft	X	(X)*		
Probe vehicle data (PVD) • aggregation of CAM • single vehicle data • travel time estimation • PVD including PDM	Concept	Draft	X X X		X
Intersection Safety (ISS)	Draft	X			
Other DENM based applications • Processing of DENM from the vehicles • TCC initiated DENMs based on traffic information content	Draft	X		X	
Multimodal information (MIF)	Feasibility Study				

Figure 23 : ECo-AT overview of uses cases and releases [ECo-AT 2017]

A high level architecture for C-ITS services is described in the system overview document. With regard to testing in the Living Lab, the architecture is also referred to in the Living Lab document. A system architecture illustration is provided in Figure 24. For communicating between the stations in the overall C-ITS "system" the specification of the interfaces are particularly important.

The following specifications are the relevant test objects for conformance testing:

- System specification of C-ITS-S [ECo-AT SWP3.1 C-ITS-S]
- System specification of R-ITS-S [ECo-AT SWP3.2 R-ITS-S]
- Interface specification of IF1: TCC<->C-ITS-S [ECo-AT SWP3.1 IF1 data]
- Interface specification of IF3: C-ITS-S<->R-ITS-S [ECo-AT SWP3.1 IF3 comm]

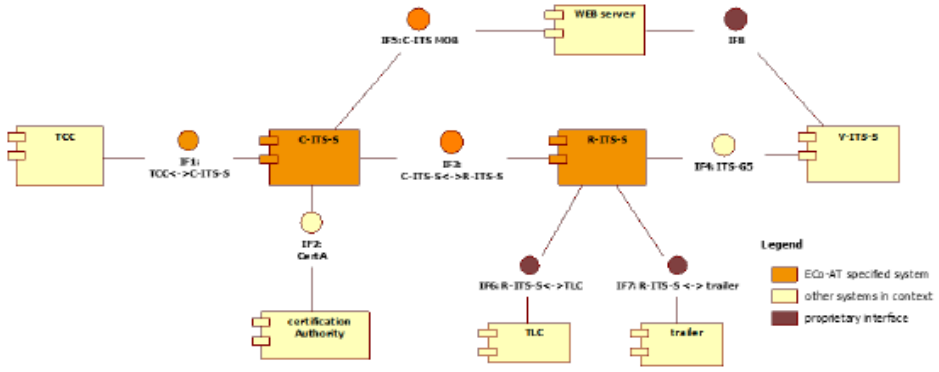


Figure 3 High level system architecture

Additionally the following components and interfaces are used, but not specified, within the ECo-AT project. These objects are relevant to the Living Lab as they are needed for interoperability and system (end-to-end) testing.

- V-ITS-S and IF4: ITS-G5

  Vehicles equipped with a V-ITS-S are the target of many use cases defined within the ECo-AT project. They are able to communicate with the R-ITS-S through the ITS-G5 interface specified by the appropriate ETSI documents. Within ECo-AT this interface is known as IF4.

- Traffic Control Center (TCC)

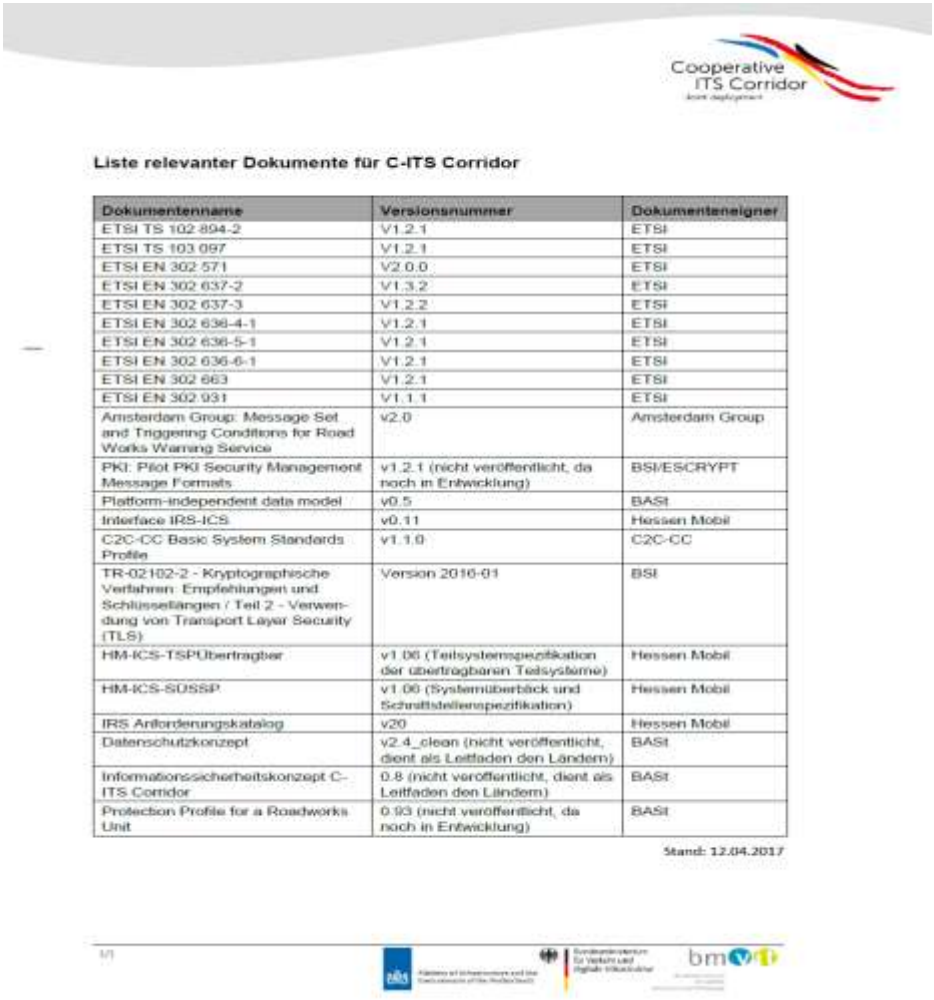
  The existing TCC from ASFINAG is responsible for traffic control. It provides traffic events that are the source for the C-ITS services and use cases disseminated via the C-ITS system.

- Certification authority (CertA)

Figure 24 : ECo-AT High Level System Architecture – Excerpt from Living Lab Document [ECo-AT 2017]

3.3.3. SHARED DOCUMENT LIST AND HARMONISED C-ITS CORRIDOR PROFILE

The C-ITS Day One system needs to be technically interoperable, based on agreed standards and an ITS system specification developed and agreed between the deployment partners from the automotive industry and infrastructure. Interoperable ITS services in vehicles together with the approach of regional, national and European cross border (e.g. corridor) deployment will then have the opportunity to support each other towards a general market take up [Amsterdam Group 2013].



Cooperative ITS Corridor

Liste relevanter Dokumente für C-ITS Corridor

Dokumentenname	Versionsnummer	Dokumenteneigner
ETSI TS 102 894-2	V1.2.1	ETSI
ETSI TS 103 097	V1.2.1	ETSI
ETSI EN 302 571	V2.0.0	ETSI
ETSI EN 302 637-2	V1.3.2	ETSI
ETSI EN 302 637-3	V1.2.2	ETSI
ETSI EN 302 636-4-1	V1.2.1	ETSI
ETSI EN 302 636-5-1	V1.2.1	ETSI
ETSI EN 302 636-6-1	V1.2.1	ETSI
ETSI EN 302 663	V1.2.1	ETSI
ETSI EN 302 931	V1.1.1	ETSI
Amsterdam Group: Message Set and Triggering Conditions for Road Works Warning Service	v2.0	Amsterdam Group
PKI: Pilot PKI Security Management Message Formats	v1.2.1 (nicht veröffentlicht, da noch in Entwicklung)	BSI/ESCRYPT
Platform-independent data model	v0.5	BASt
Interface IRS-ICS	v0.11	Hessen Mobil
C2C-CC Basic System Standards Profile	v1.1.0	C2C-CC
TR-02102-2 - Kryptographische Verfahren: Empfehlungen und Schlüssellängen / Teil 2 - Verwendung von Transport Layer Security (TLS)	Version 2016-01	BSI
HM-ICS-TSPÜbertragber	v1.00 (Teilsystemspezifikation der übertragbaren Teilsysteme)	Hessen Mobil
HM-ICS-SÜSSP	v1.00 (Systemüberblick und Schnittstellenspezifikation)	Hessen Mobil
IRS Anforderungskatalog	v20	Hessen Mobil
Datenschutzkonzept	v2.4_clean (nicht veröffentlicht, dient als Leitfaden den Ländern)	BASt
Informationssicherheitskonzept C-ITS Corridor	0.8 (nicht veröffentlicht, dient als Leitfaden den Ländern)	BASt
Protection Profile for a Roadworks Unit	0.93 (nicht veröffentlicht, da noch in Entwicklung)	BASt

Stand: 12.04.2017

Figure 25 : Shared list of relevant documents for the C-ITS Corridor (Status: April 2017) [C-ITS Corridor 2017]

Cross-national harmonisation of services between Austria, Germany and the Netherlands in the C-ITS corridor is encouraged by a shared list of documents. The list (status: April 2017) is reproduced in Figure 25.

Besides functional specification of services (see previous chapters) it is also important to provide interface specifications on a very deep level, even down to byte-wise according to the message standards (e.g. CAM and DENM). With a view towards interoperability of C-ITS services on European scale it should be noted that not all interfaces need to be specified in a similar way. Most important is that vehicles and road side (IF 4 in context and terminology of ECo-AT, see above) “understand” each other. While the Car2Car Communication Consortium has released a Basic System Profile (BSP), A first effort in harmonising this communication interface is provided by the Harmonised C-ITS Corridor Profile [C-ITS Corridor 2016]. The introduction part of the profile, informing about the scope of the document, is represented in Figure 26. The profile deals with ITS G5 as providing one communication medium in a hybrid communication approach.

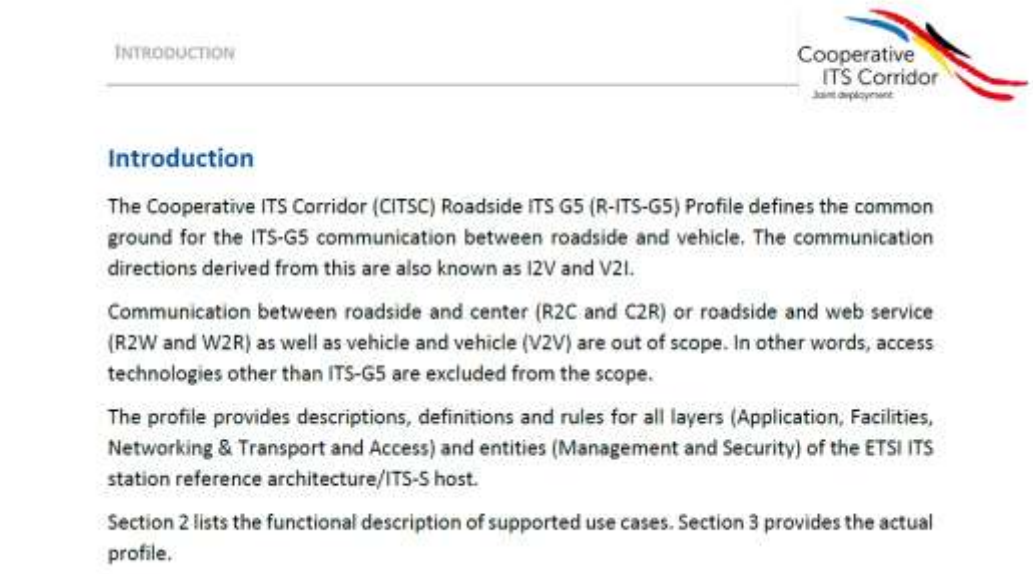


Figure 26 : Cooperative ITS Corridor – Cross Border Harmonisation, Harmonised ITS G5 Profile [C-ITS Corridor 2016]

4. Profiling issues

4.1. Interoperability challenge

Interoperability is key, for C-ITS services but also beyond. As the European Commission's C-ITS Strategy points out (COM (2016) 766 final) [C-ITS Strategy 2016], "an integrated transport system relies on the interoperability of its components. They need to be able to interact with each other, across borders and transport modes, at all levels: infrastructure, data, services, applications and networks." As the previous chapters have illustrated, standards are essential but not sufficient to ensure interoperability. What has to come on top is a shared understanding and consistent application of standards.

In a process view, when the depth of specification (y-axis) is mapped against the technological readiness (x-axis, which correlates with the timeline), as illustrated by Figure 27, it becomes visible that the degrees of freedom more and more diminish and the details become more and more fixed. However, even at the stage of deployment some degrees of freedom remain, related to those issues which are critical with regard to interoperability. In the context of ITS stations in vehicles and at roadside, it is important that interoperability at the "air interface" is ensured by sending messages with mutually agreed profiled values that can be understood by the receiver side. However, it is not strictly necessary (although may be desirable) to speak the same language also between roadside and central ITS station.

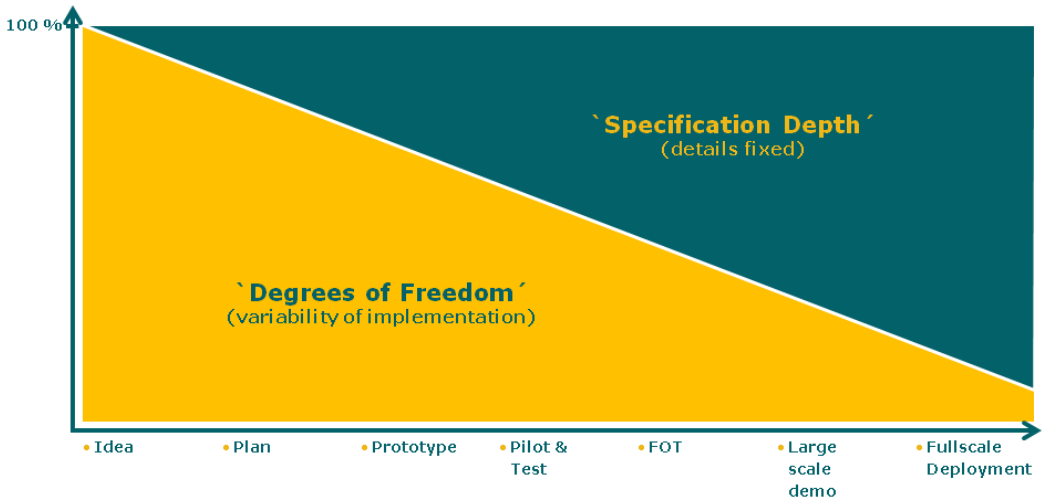


Figure 27 : Interoperability challenge [Berndt et al. 2017]

The Day One C-ITS deployment builds on a hybrid communication concept, making use of ETSI ITS G5 and existing cellular networks [C-ITS Strategy 2016]. The automotive industry, represented by the Car2Car Communication Consortium (C2C-CC), has developed specifications and a Basic System Profile (BSP) for ETSI ITS G5 communication part:

- The Basic System Profile focuses on specifying the basic system on the transmitting side of Vehicle ITS Stations whereas the receiving side is not in its scope. This choice is motivated by the fact that message reception, information integration and display in the HMI of the vehicle falls under the competitive area of OEMs.
- The BSP also aims at fulfilling the use case requirements stemming from the road safety domain, see list of Day 1 services (Figure 3), including e.g. Emergency Vehicle Warning, Emergency Brake Light, Slow and Stationary Vehicle Warning, Traffic Jam Ahead Warning, Adverse Weather Conditions.
- To some extent, the BSP also reaches out to the receiving side but only in so far that messages typically transmitted from infrastructure (Roadside ITS stations, Central ITS stations) can be correctly understood. This subset of Day 1 services typically comprises e.g. Road Works Warning, In-Vehicle Signage/Information, Hazardous Location Notification, Green Light Optimal Speed Advisory (GLOSA) and Probe Vehicle Data.

4.2. Profiling sunflower

In an overall C-ITS system where vehicles and infrastructure (and may be also others) transmit messages, the vehicle BSP needs an infrastructure counterpart. It is however important to keep the following in mind:

- OEMs operate their business on a competitive basis on a global market scale. Some regional (in terms of world regions) differences exist, e.g. a Basic Safety Message (BSM) is similar to the European message formats CAM and DENM but not identical. The geographical scope for the vehicles is Europe, the vehicles can be driven across (national) borders and the expectation of drivers is hence that services are not tied to a limited geographical area.
- Road authorities and operators provide (or let provide) as part of their portfolio traffic information and warnings in their jurisdiction. This represents a joint but geographically separated responsibility. The service as such constitutes a non-tradeable service. With regard to drivers expectations however there is a need for interoperability and harmonisation.

The stylised facts imply that there is more than one counterpart of the Basic System Profile. Each pilot and deployment initiative has functionally specified the services and profiled the minimum set of standards. As C-ITS deployment in Europe has developed into a fertile deployment base, the C2C-CC Basic System Profile has got many counterparts on the infrastructure side. This fact is illustrated by the "Profiling Sunflower" as represented in Figure 28.

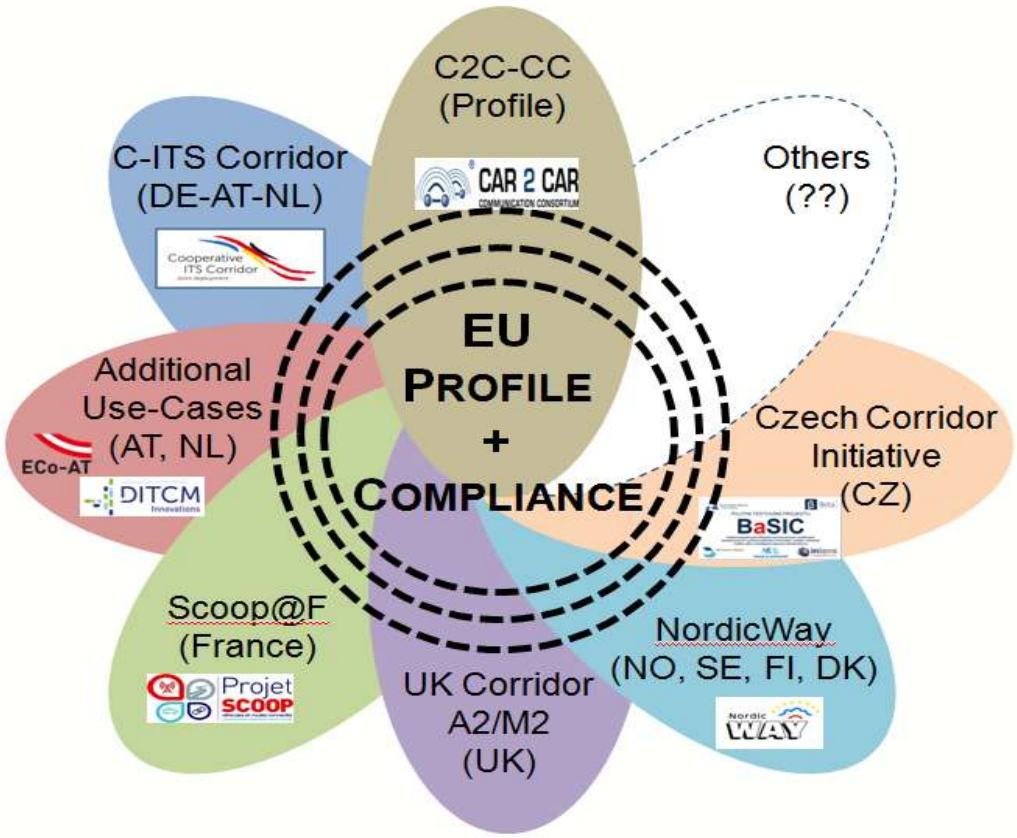


Figure 28 : Profiling Sunflower [Spaanderman 2015]

In order to provide seamless and interoperable services it is necessary for road authorities and operators to agree on a harmonised infrastructure profile. This forms then also the basis for compliance assessment. The development and agreement of a harmonised infrastructure profile should be done by an institution of sufficient European scale. The C-Roads Platform, providing the implementation level umbrella to the C-ITS pilots and deployment initiatives, is uniquely positioned to fulfil this task.

5. Common Requirements Engineering

5.1. Intended collaboration

The importance of developing and agreeing on harmonised profiles has been stressed before. For performing the task of common requirements engineering the specific strenghts of different C-ITS related actions can be combined (see Figure 29):

- C-Roads is the flagship initiative for Member States driven pilots and deployment initiatives on C-ITS services. The platform is in an unique and exposed position for the harmonisation of the infrastructure profile.
- The EU ITS Platform (EU EIP) involves to a large extent similar organisations. It has however a broader portfolio of activities centered around ITS deployment. The knowledge and capabilities that have been built in predecessor collaboration activities for almost two decades can be brought into the process in order to achieve the best integration of C-ITS pilots with the current ITS deployment.
- CODECS as a Horizon 2020 CSA brings in the asset of cross-sector representation of core actors in C-ITS deployment.

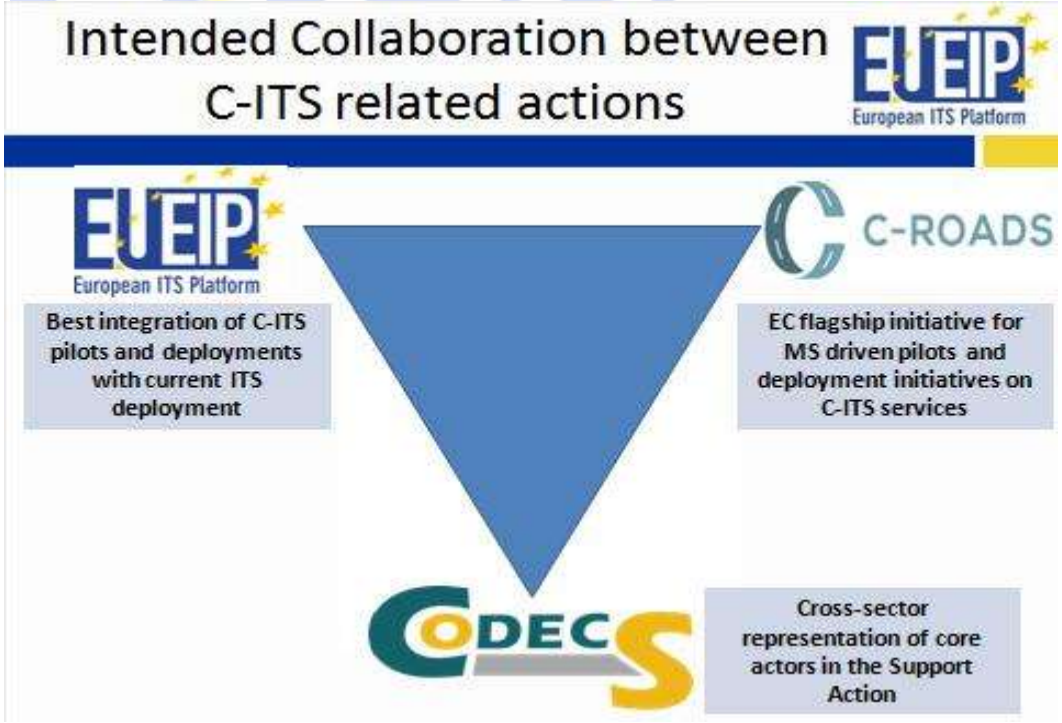


Figure 29 : Intended collaboration between C-ITS related actions

5.2. Process

The C-ITS activity in the EU EIP study broadly comprises three tasks (activity areas). All of them, as listed below, produce recurrent output in the lifespan of the activity until 2020 (see Figure 30):

- 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.

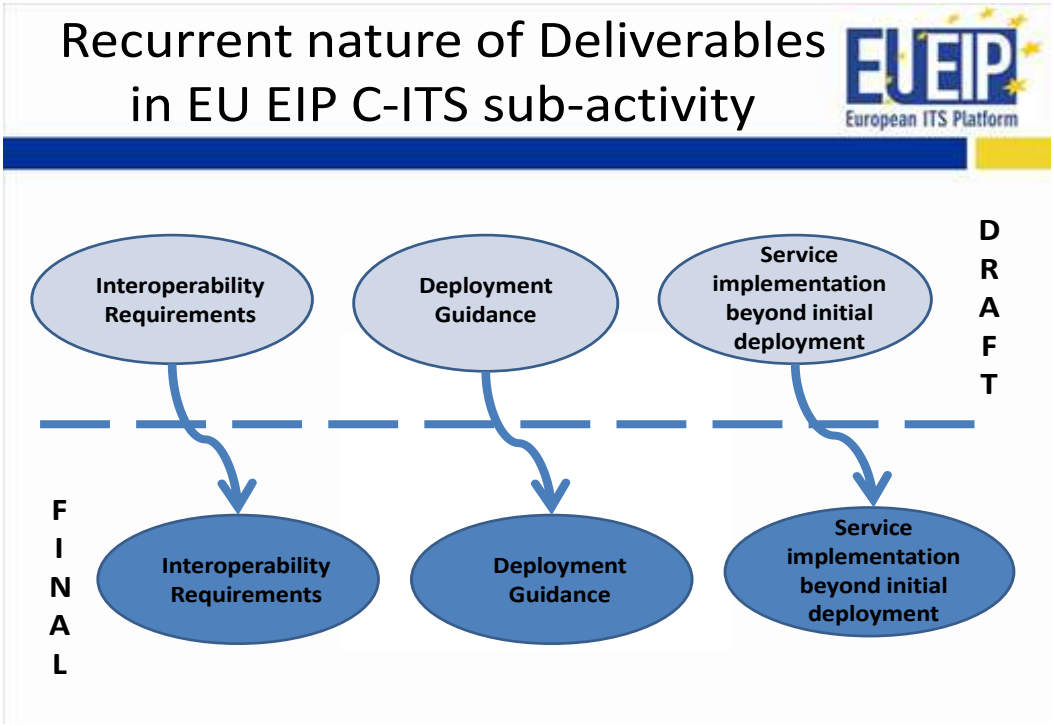


Figure 30 : Recurrent nature of Deliverables in the C-ITS activity

The triangular collaboration between the actions, as described above, can be put in place the following way. This EU EIP C-ITS deliverable provides input to the C-Roads process of developing the infrastructure communication profile. C-Roads output is also commented and enriched by CODECS. These findings will then be integrated in the updated final version of this EU EIP C-ITS deliverable. The proposed process is illustrated in Figure 31.

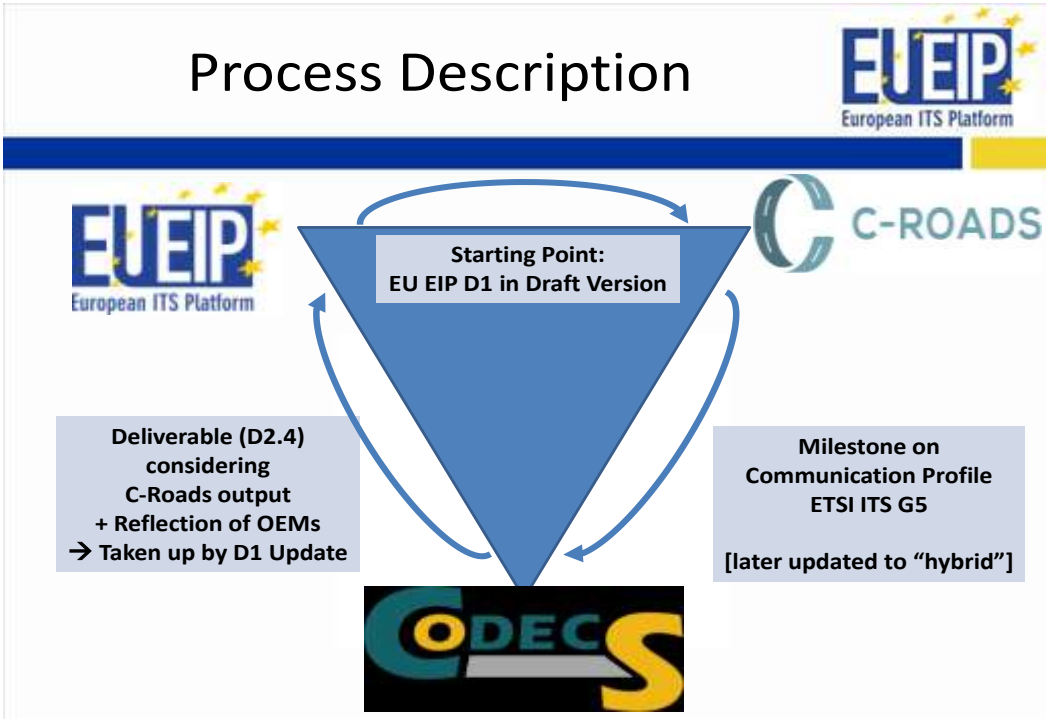


Figure 31 : Process of collaboration

The process as illustrated in Figure 31 should be viewed as an idealised process of guiding nature. In practice, the interaction is much closer with many micro-feedback loops in order to achieve the shared goal in an efficient way. This also considers the close cooperation of C-Roads with the Car2Car Communication Consortium, as formalised by the Memorandum of Understanding signed in June 2017. It provides a shortcut between the owners of the C2C Basic System Profile and its infrastructure counterpart.

Meanwhile, a first release of C-Roads profiles on infrastructure-to-vehicle communication for a bundle of Day One Services has become available in September 2017 [C-Roads 2017]. The release covers Road Works Warning (RWW), In Vehicle Signage (IVS), Other Hazardous Location Notification (OHLN) and Green Light Optimal Speed Advisory (GLOSA).

6. Outlook

The work within the EU EIP C-ITS activity on interoperability requirements for C-ITS services with infrastructure involvement will lead to updates triggered basically by two processes.

This current document represents a draft version. Making use of the common requirements engineering process as illustrated in chapter 5 will result in a final version of the Deliverable by September 2018.

More broadly, the work and its output has to be conscious of the progress on the European framework towards deployment of C-ITS services and the anticipation of vehicle automation. The fundaments of this path have been laid in the C-ITS strategy as "a milestone towards cooperative, connected and automated mobility" [EC 2016]. The evolution of the process as described in chapter 2, also involving a platform on cooperative, connected and automated mobility (CCAM), is illustrated in Figure 32, as presented in the concluding Plenary Meeting of the C-ITS Platform second phase in September 2017.

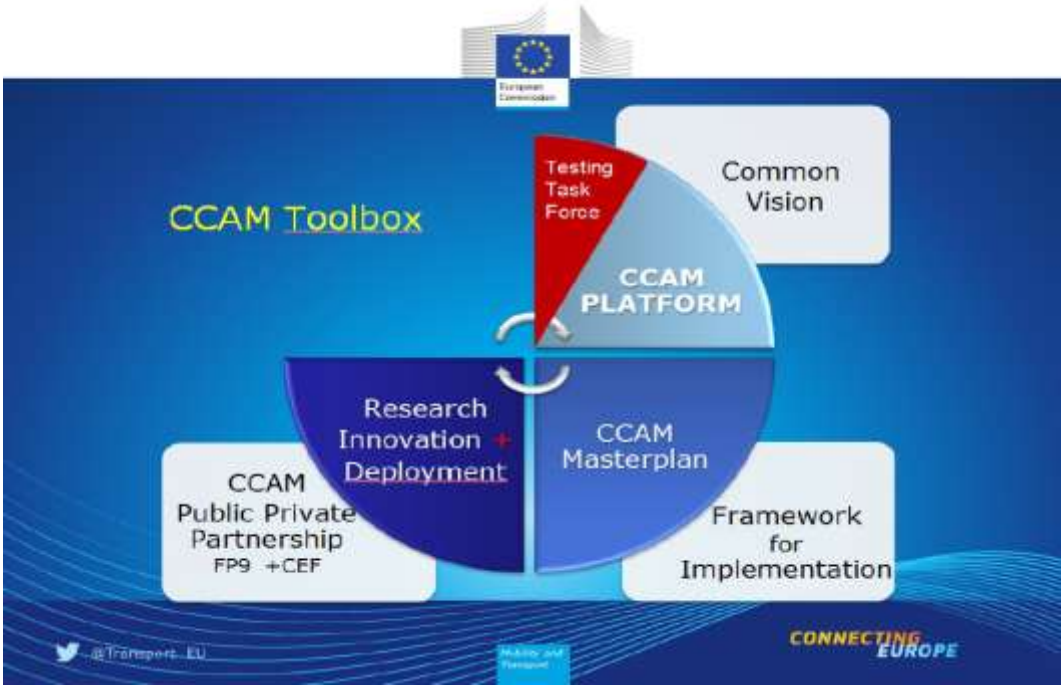


Figure 32 : Evolution towards Cooperative, Connected and Automated Mobility (CCAM) [EC 2017]

7. References

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