Council of the
European Union

Brussels, 14 March 2019
(OR. en)

7510/19
ADD 6

TRANS 199
DELACT 68

COVER NOTE

From:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
date of receipt:	13 March 2019
To:	Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union
No. Cion doc.:	SWD(2019) 96 final - PART 1/2
Subject:	COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT Accompanying the document Commission Delegated Regulation supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the deployment and operational use of cooperative intelligent transport systems

Delegations will find attached document SWD(2019) 96 final - PART 1/2.

Encl.: SWD(2019) 96 final - PART 1/2

EUROPEAN
COMMISSION

Brussels, 13.3.2019
SWD(2019) 96 final

PART 1/2

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Commission Delegated Regulation

supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the deployment and operational use of cooperative intelligent transport systems

{C(2019) 1789 final} - {SEC(2019) 100 final} - {SWD(2019) 95 final}

Table of contents

Glossary

Term or acronym	*Meaning or definition*
3GPP	3rd Generation Partnership Project
5G	5th generation of communication networks
CCAM	Connected, Cooperative and Automated Mobility
CEPT	European Conference of Postal and Telecommunications Administrations
C-ITS	Cooperative Intelligent Transport Systems
CP	Certificate Policy for C-ITS security
EEA	European Environmental Agency
GDP	Gross domestic product
GDPR	General Data Protection Regulation
GSR	General Safety Regulation
IRC	Impact Reduction Container
ITS	Intelligent Transport Systems
ITS-G5	IEEE 802.11p (wifi) communications protocol for C-ITS communication
I2I	Infrastructure-to-infrastructure communication
LTE	Long Term Evolution
LTE-V2X or C-V2X	Cellular communications protocol for C-ITS communication
RISM	Road Infrastructure Safety Management
RSU	Road-side unit
SP	Security Policy for C-ITS security
CCMS	C-ITS Security Credential Management System
V2I	Vehicle-to-infrastructure communication
V2V	Vehicle-to-vehicle communication
V2X	Vehicle-to-everything communication
VOC	Volatile Organic Compounds (air pollutants)
VRU	Vulnerable Road User

1. INTRODUCTION

The increasing volume of road transport in the European Union poses several challenges. Road transport is responsible for the bulk of transport emissions, in terms of greenhouse gases and air pollutants. While there have been improvements in road safety in the EU over the last few decades, this trend has recently slowed down and it is unlikely that the EU will reach the objective of a 50 percent reduction in fatalities between 2010 and 2020. Finally, congested roads incur huge costs to the EU economy. Coordinated action across a number of fronts is required to tackle these issues and prevent them from having strong negative effects on the European population, economy, environment and climate.

The development of new technologies aimed at improving the efficiency, safety and environmental performance of road transport are playing a significant role in achieving the Commission's goals in this area. One such emerging field is that of Cooperative Intelligent Transport Systems (C-ITS).[1] C-ITS enable vehicles to interact directly with each other and with the surrounding road infrastructure. In road transport, C-ITS typically involves communication between vehicles (Vehicle-to-Vehicle, V2V), between vehicles and infrastructure (Vehicle-to-Infrastructure, V2I) and/or Infrastructure-to-Infrastructure (I2I), and between vehicles and pedestrians or cyclists (Vehicle-to-everything, V2X), which enable a wide range of information and cooperation services.

The benefits of C-ITS span a range of areas, including improving road safety, reducing congestion, optimising transport efficiency, enhancing mobility, increasing service reliability, reducing energy use and environmental impacts, and supporting economic development. At the same time, attention should be given so that potential negative effects of C-ITS are avoided, e.g. that these improvements lead to induced traffic demand, drivers experience information overload due to information coming from numerous sources, or that the additional data sharing leads to increased cyber security or privacy risks.

Over the past decade, there have been remarkable new developments in technologies that facilitate C-ITS. However, this has not yet led to large-scale deployment despite the potential benefits. In 2011, the EU car manufacturers united in the CAR2CAR consortium[2] stated their intention to start large-scale deployment by 2015 in a Memorandum of Understanding[3], as the system would be technologically ready by then. However, it became clear that this large-scale deployment was not possible without a common approach between the main stakeholders on both technical and non-technical aspects.

This is why the Commission created the C-ITS Platform, a Commission expert group conceived as a cooperative framework including national authorities, C-ITS stakeholders and the Commission, in view to develop a shared vision and concrete implementation solutions for the interoperable deployment of C-ITS in the EU. The results of the extensive work of the platform

1 Annex 5 includes a more detailed description on the general functioning of C-ITS services and the specific services (day 1 & day 1.5) considered in the analysis.

2 Including 18 vehicle manufacturers, 40 equipment suppliers and 31 research organisations.

3Available at https://www.car-2-car.org/

and its working groups was summarized in the final reports of Phase I (2014-2016) and Phase II (2016-2017).[4]

Within the C-Roads Platform and through significant investments at national and EU level (EUR 199 million, of which 107 EUR million co-funded through the Connecting Europe Facility), 16 Member States have started work to harmonise V2I C-ITS services and make them interoperable, allowing for example messages about road-works to be understood consistently across different geographical environments. Through further cooperation with the CAR2CAR consortium, increased consistency has been achieved in vehicle to vehicle and vehicle to infrastructure messages.

This work of the C-ITS platform was an essential input in the European strategy on Cooperative Intelligent Transport Systems (COM(2016)766)[5], which aimed to facilitate the convergence of investments and regulatory frameworks across the EU, in order to enable deployment as quickly as possible, starting with mature C-ITS services in 2019. It also clearly sets out the need to adopt an appropriate legal framework at the EU level by 2018, possibly through delegated acts under the ITS Directive or other legal instruments.

Deploying these services and connecting all vehicles with each other and all infrastructure operators also requires a common security solution. This is a necessary condition to ensure trust in an open system. At the same time, the strategy defined the so-called hybrid communication approach, which combines complementary and mature technologies for a full and optimal implementation of all services.

All these elements constitute minimal requirements for interoperability, backward compatibility and continuity of services. Most stakeholders agree that without a clear legal framework, deployment will remain slow and fragmented (81% of respondents (strongly) agreed in the public consultation (PC)) as a result of the problem drivers identified (70-80% of respondents felt that the different problem drivers were very or moderately important) and that the objectives should be achieved at EU level (68-86% considered that is was absolutely essential or very important that the different objectives are achieved through EU, rather than national or international action).

The subject of this initiative is creating the legal framework for C-ITS, incorporating the minimum requirements for interoperability, as mandated by the ITS Directive, to enable the start of large-scale deployment in 2019. The focus lies on "Day 1" and "Day 1.5" services[6], C-ITS services that will be deployed in the short and medium term and which contribute particularly to improve road safety and traffic efficiency. Specifications and standards for interoperable Day 1 services, as well as a common security solution, are now available as a result of cooperation between a broad group of industry stakeholders and MS authorities.

4 More information of the C-ITS platform and its deliverables, including the Phase I and II final reports can be found at: https://ec.europa.eu/transport/themes/its/c-its_en

5 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016DC0766 , from now on referred to as "C-ITS Strategy"

6 Day 1.5 C-ITS services are considered to be mature, but not quite ready for a large-scale deployment due to a lack of full specifications or standards, and so would be deployed somewhat later. A description of the functioning and classification of all Day 1 and Day 1.5 services considered in this IA can be found in Annex 5.

1.1. Policy and legal context

1.1.1. EU Policy context

In 2008, the Commission adopted an action plan for the deployment of Intelligent Transport Systems (ITS) in the EU (COM(2008)886 final)[7], which identified the potential of C-ITS and that its development should be promoted, in particular by defining a harmonized approach and specifications, as well as through a mandate to the European Standardisation Organisations (ESOs) to develop harmonised standards.

This 2009 mandate (M/453 EN)[8], indicated that a sufficient critical market mass is needed to achieve the potential of C-ITS and that common specifications and standards are needed to ensure interoperability and continuity of C-ITS services across the EU. While the development of these specifications and standards is principally carried out by the industry, the mandate already indicates that to ensure true EU-wide interoperability essential parts of the standards would need legal enforcement measures.

The Commission's 2011 Transport White Paper (COM(2011)144 final)[9] sets the framework within which EU transport policy is currently developed. While it did not make an explicit reference to C-ITS, it clearly identified the need and relevant initiatives to develop and deploy Intelligent Transport Systems (ITS).

The Roadmap for the Energy Union (COM(2015)80 final)[10] and the ensuing Low Emission Mobility Strategy (COM(2016)501 final)[11] stated that a EU framework for the deployment of C-ITS should be provided, which was delivered through the C-ITS Strategy.

On 13th March 2018 the European Parliament adopted an opinion on the C-ITS Strategy.[12] The opinion calls for the introduction of interoperable C-ITS services throughout Europe without delay and highlights the need for a clear legal framework to support the deployment of C-ITS. The opinion considers that in the further development of C-ITS, the link to cooperative, connected and automated mobility and urban driving, including interaction with vulnerable road users, should get additional attention.

Link to cooperative, connected and automated mobility

The deployment of cooperative, connected and automated mobility (CCAM) – when fully integrated in the whole transport system and accompanied by the right support measures and synergies between driverless mobility and decarbonisation measures – is expected to contribute significantly to bringing down the number of road fatalities, reducing harmful emissions from transport and reducing congestion.

The ability of vehicles to communicate will be key to integrate automated vehicles in the overall road transport system, including its interfaces with other modes. For example, C-ITS can improve an automated safety feature such as adaptive cruise control, by more quickly informing the

7 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0886:FIN:EN:PDF

8 http://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=search.detail&id=434

9 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52011DC0144

10 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0080&from=EN

11 https://eur-lex.europa.eu/resource.html?uri=cellar:e44d3c21-531e-11e6-89bd-01aa75ed71a1.0002.02/DOC_1&format=PDF

12 http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P8-TA-2018-0063&language=EN&ring=A8-2018-0036

system about changes in other vehicle's speed than possible through cameras, and help vehicles perform complex manoeuvres such as lane-merging and overtaking, which cannot (or not as efficiently) be done by automation alone.[13] This cooperation will also help optimizing the performance of the whole transport network, rather than the performance of the individual vehicle alone. C-ITS are thus a key initial component in the broader development towards CCAM (including the work towards a pan-EU network of 5G Corridors for CCAM) and there is a clear need for the convergence between connectivity and automation.

That is why, in the Declaration of Amsterdam[14], the Transport Ministers called upon the Commission to work towards a coherent European framework for the deployment of interoperable connected and automated driving, which should be available, if possible, by 2019.

The 'Europe on the Move' Communication (COM(2017)283 final)[15], discusses the role of C-ITS in enabling cooperative, connected and automated mobility (CCAM).[16] It highlights the need for demonstration projects, the importance of developments in communication technologies, and the relevance of work being undertaken in the context of the Digital Single Market Strategy.

Compatibility between infrastructure and vehicle solutions for safety, traffic efficiency and automation will need to be assured across the EU in order to fully benefit from these solutions. This shows how important a holistic approach is. That is why the Third mobility package, adopted by the Commission in May 2018[17], combined a new road safety policy, with legislative proposals on vehicle and pedestrian safety[18] (COM(2018)286 final – General Safety Regulation(GSR)) and on infrastructure safety management[19] (COM(2018)274 final – Directive on Road Infrastructure Safety Management (RISM)).

The package also included an EU strategy for connected and automated mobility[20] (COM/2018/283 final), which sets out a common vision for the future development of the sector and ensuring that the EU legal and policy framework on key issues is ready for the market deployment of new products and services. The Commission prepared the ground for this strategy with an extensive stakeholder and Member State consultation process, in particular through the C-ITS platform and the GEAR 2030 high-level group which adopted recommendations[21] on automated and connected vehicles on 18 October 2017.

13 Studies have quantitatively shown that automation without connectivity could potentially lead to worsening traffic conditions: https://ec.europa.eu/jrc/en/publication/connected-and-automated-vehicles-freeway-scenario-effect-traffic-congestion-and-network-capacity

14 https://www.regjeringen.no/contentassets/ba7ab6e2a0e14e39baa77f5b76f59d14/2016-04-08-declaration-of-amsterdam---final1400661.pdf

15 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0283&from=EN

16 The concepts of "Connected, Cooperative and Automated Mobility" and "Connected and Automated Mobility" are used in parallel. This document makes reference to Connected, Cooperative and Automated Mobility and its acronym (CCAM) wherever possible.

17 See https://ec.europa.eu/transport/modes/road/news/2018-05-17-europe-on-the-move-3_en for further details.

18 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018PC0286

19 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018PC0274

20 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0283

21 https://ec.europa.eu/growth/content/high-level-group-gear-2030-report-on-automotive-competitiveness-and-sustainability_en

1.1.2. EU Legal context

The main legal and policy framework for C-ITS is set by the ITS Directive (Directive 2010/40/EU) and the 2008 ITS Action Plan.

One of the main obligations for the Commission in the ITS Directive is to adopt specifications ensuring compatibility, interoperability and continuity for the deployment and operational use of ITS in different priority areas (Article 6(3) of the Directive). C-ITS is covered under priority area IV – "Linking the vehicle with the transport infrastructure". The Annex of the Directive (Priority Area IV, point 1.2)[22] defines that these specifications and standards shall include i.a. (1) the use of a standardised message format for the exchange of data or information between the vehicle and the infrastructure (2) the definition of a communication infrastructure for data or information exchange between vehicles, infrastructures and between vehicle and infrastructure and (3) the use of standardisation processes to adopt the respective architectures.

At the same time, the framework for electronic communications and the protection of personal data has significantly evolved over the last years.

- The General Data Protection Regulation (EU) 2016/679 repealing Directive 95/46/EC provides a comprehensive legal framework concerning personal data, to which also C-ITS shall comply.

- In addition, the following Directives contain additional rules on data protection and electronic communication that can be relevant for C-ITS:

    - Directive 2002/58/EC 'concerning the processing of personal data and the protection of privacy in the electronic communication sector' (and the proposed Regulation to replace the Directive (COM (2017)10 final).
    - Directive 2002/19/EC 'on access to, and interconnection of, electronic communications networks and associated facilities (Access Directive)' and its proposed recast (COM(2016)590 final).

The GSR is regularly updated to include new mandatory safety features to vehicles, the impacts of which can overlap with or be reinforced through C-ITS. A new proposal[23] proposes to include inter alia advanced emergency braking, lane-keeping assist system and pedestrian and cyclists' detection systems for trucks.

1.1.3. International cooperation

International cooperation in the area of cooperative, connected and automated vehicles is fundamental as markets are developing globally. The EU has already benefitted from cooperation with Australia, Japan, Singapore and the US in areas such as research, security and harmonisation of standards.

22 It should be noted that action on (Priority Area IV, point 1.1) on an open-vehicle platform and the broader topic of access to in-vehicle data, is outside the scope of this initiative.

23 REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users, amending Regulation (EU) 2018/… and repealing Regulations (EC) No 78/2009, (EC) No 79/2009 and (EC) No 661/2009

The EU should continue engaging with international partners to continue benefitting from their experiences, especially those gained from large-scale deployment initiatives. This includes promoting international standardisation (e.g. vehicle regulation and traffic rules in the United Nations Economic Commission for Europe), protecting the privacy of individuals and their personal data and cyber security, addressing legal aspects and enabling the coordination of research (e.g. through twinning of Horizon 2020 research and innovation projects).

2. PROBLEM DEFINITION

Figure 1: intervention logic presents the intervention logic of the initiative, identifying the general problem, the main problems and problem drivers, as well as the general and specific objectives.

2.1. General problem: Limited deployment and uptake of continuous C-ITS services across the EU

The general problem that the initiative intends to tackle is the limited deployment and uptake of continuous C-ITS services across the EU, and the resulting negative impacts on the development of connected, cooperative and automated mobility in the EU.

NOTE: This Impact Assessment focuses on the deployment of Day 1 C-ITS services which will be deployed in the short term. While the same problems also apply to Day 1.5 and later C-ITS services, and the analyzed measures/options will thus also have an impact on their deployment, common specifications for these have not yet been developed, are thus not part of the measures considered.

Some specific considerations on Day 1.5 and later C-ITS services are made in the report where relevant, and the impacts of deploying Day 1.5 services is considered as part of the sensitivity analysis in Section 6.4.

The technology for C-ITS is ready and its potential positive impacts on road safety and traffic efficiency have been clearly demonstrated in research and pilot projects. Early deployment projects are currently working on putting interoperable solutions across the EU in place, supported by national and EU funding. However, these initiatives are still fragmented and a clearer framework is needed to ensure that existing and new deployments deliver continuous C-ITS services across the EU. The Amsterdam Declaration and the European Strategy on C-ITS have both highlighted the risk that without an EU level framework, C-ITS deployment and the uptake of C-ITS services will be limited and fragmented.

Without coordinated deployment and quick uptake, the societal, economic and environmental benefits of C-ITS services will fall below their full potential, in particular because C-ITS services exhibit strong network effects. This is because C-ITS enabled vehicles will only be attractive if they can exchange messages seamlessly with a significant number of other transport participants and infrastructure; after which the addition of new services and participants will often have no or marginal extra costs for the existing users.

If on the other hand, solutions are implemented in redundant, non-interoperable systems and services, which is likely as a large number of very different stakeholders are involved, this will lead to a worse cost-benefit ratio for involved stakeholders. This creates the risk that the market may not develop further as no stakeholder may be willing to undertake significant investments as

a first mover in this case. The direct implication is that stakeholders need to agree on the (mature) technologies to be used for initial deployment. This does not preclude however that the C-ITS network remains open to the integration of new solutions and technologies[24].

High level of negative externalities caused by road transport

The deployment of C-ITS services is expected to contribute significantly to bringing down the number of road incidents, reducing congestion and reducing harmful emissions from transport.[25] These still form important negative externalities of road transport that need to be reduced.

In 2016, 25,620 people were killed on EU roads and about 246,000 were seriously injured[26]. For the period 2010-2015, fatalities for all road users decreased by 16%, whereas fatalities of vulnerable road users decreased by 13%, but the reduction has slowed down in recent years.[27] The number of vulnerable road users and therefore their exposure to risk is likely to increase, in particular in urban areas, as a result of the promotion of more sustainable modes of transport.

Under the Baseline scenario (see section 2.5), passenger transport activity (measured in passenger-km) is projected to increase by about 24% between 2015 and 2035 while road and rail freight activity (measured in tonne-km) increase by 39% during the same period. With growing demand for transport, congestion is an increasingly important issue. Congestion results in considerable economic, social and environmental costs, which according to various scientific estimations amount to 1-2% of EU GDP i.e. EUR 146-293 billion per year[28]. According to (Fermi & Fiorello, 2016), only the cost of delays from congestion accounted for EUR 140 billion /year or 1% of GDP in 2015. However, congestion not only results in delays[29] but also in a waste of fuel and additional CO_2 and air pollutant emissions. Ultimately, it leads to loss of competitiveness.

Transport (including international maritime) was responsible for 27% of EU greenhouse gas emissions in 2016; road transport accounted for 72% of these. GHG emissions from road transport in 2016 were still 22% higher than in 1990.

According to recent estimates[30], air pollution from road transport costs up to 2% of GDP to society. The impact of this is felt especially in major urban areas across Europe[31], but it cannot be neglected on inter-urban routes. According to the EEA, the total number of premature death

24 See section on communication technologies for more details

25 The expected impact of the mature day 1 and 1.5 services is described in Annex 5.

26 Source: CARE database, based on police reports.

27 -1.3% between 2013 and 2016

28 Numerous sources, including: CE Delft, INFRAS, Frauenhofer ISI, External Costs of Transport in Europe, Delft, November 2011. Christidis, Ibanez Rivas, Measuring road congestion, JRC Technical Notes, 2012; Fermi, F., & Fiorello, D. (2016). Study on Urban Mobility – Assessing and improving the accessibility of urban areas - Task 2 Report – Estimation of European Urban Road Congestion Costs.

29 Victoria Transport Policy Institute, Transportation Cost and Benefit Analysis II – Congestion Costs: http://www.vtpi.org/tca/tca0505.pdf

30 OECD (2014), The Cost of Air Pollution: Health Impacts of Road Transport, OECD Publishing. http://www.oecd.org/env/the-cost-of-air-pollution-9789264210448-en.htm.

31 See e.g. http://www.irceline.be/en/air-quality/measurements/nitrogen-dioxide/history for Belgium

attributable to air pollution in the EU was around 500.000 in 2013[32], with emissions from road transport being a main contributor.

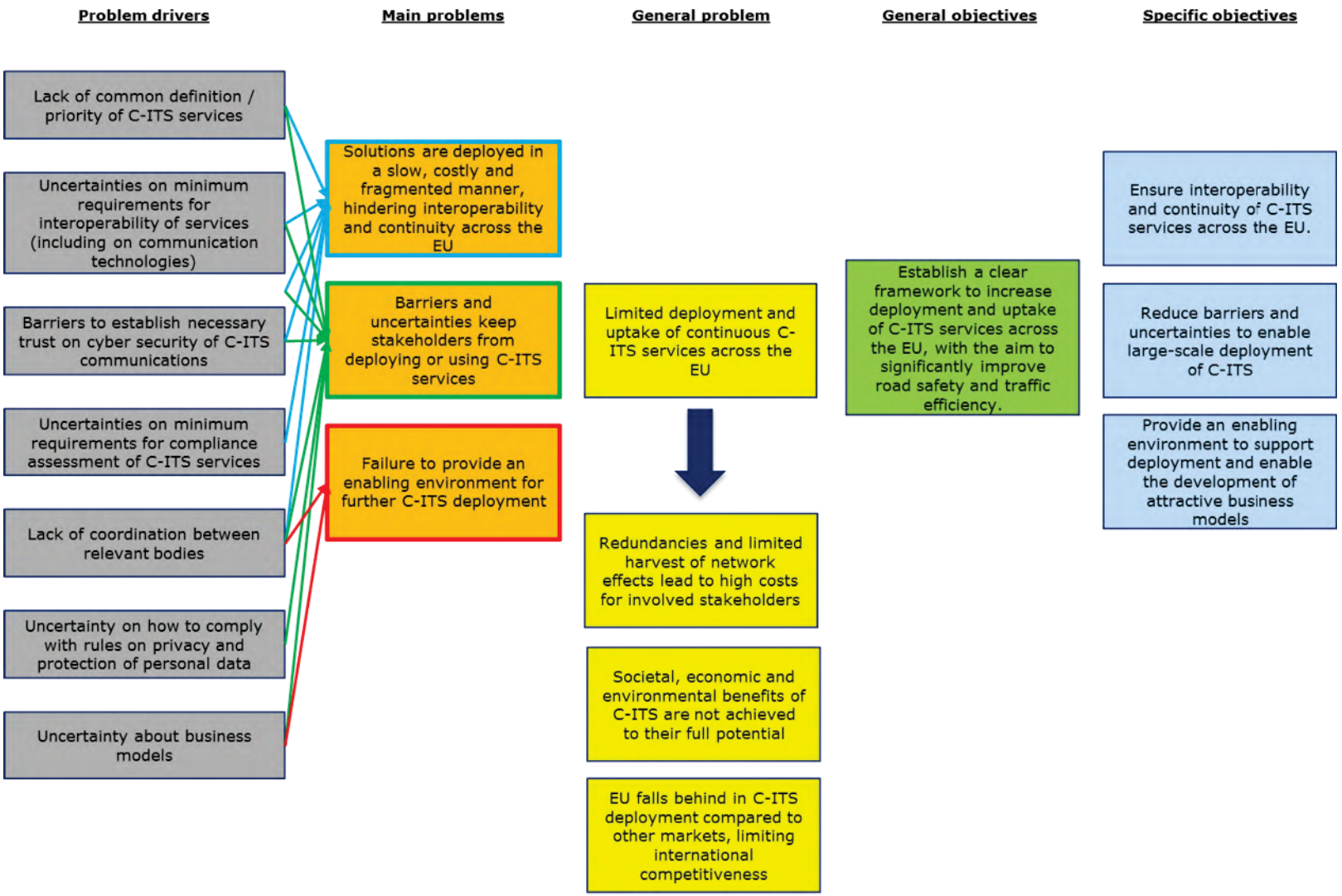
Competitiveness

Countries around the world (e.g. US, Australia, Japan, Korea and China) are moving rapidly towards deploying digital technologies in road transport; Japan has already equipped 2.5 million vehicles with short-range communication for a limited set of services. Delays to C-ITS (and consequentially CCAM) deployment would put the European automotive and ITS industry at a disadvantage compared to its competitors, leading to lower levels of new business opportunities and job creation, and less significant research and innovation impacts. As the jobs of millions of Europeans depend directly or indirectly on the automotive industry (12 million people, accounting for 4% of GDP)[33], it is critical that the sector is provided with the conditions to keep up with global market players.

32 http://www.eea.europa.eu/highlights/stronger-measures-needed/table-10-1-premature-deaths

33 https://ec.europa.eu/growth/sectors/automotive_en

Figure 1: intervention logic



2.2. Main problems

The general problem identified in the previous section is a result of a number of main problems.

2.2.1. Main problem 1: Solutions are deployed in a slow, costly and fragmented manner, hindering interoperability and continuity across the EU.

The current deployment of C-ITS is characterized by individual projects across the EU. While vehicle manufacturers, road authorities and other stakeholders work together to develop common solutions, many stakeholders consider that without a common framework, we risk a patchwork of C-ITS services, resulting in slow, costly and fragmented deployment, thus hindering the interoperability and continuity of C-ITS services. Continuity of service, i.e. the availability of C-ITS services across the EU for end-users, is the most important factor for swift deployment of C-ITS as highlighted in the C-ITS Strategy.

Considering that the EU has a single market for vehicles and a single European Transport Area, and the complexity due to the number of different stakeholders involved, many consider that a framework at EU, rather than national or international level, is needed. This is also reflected internationally, where there is significant deployment in Japan were such a framework exists, and the US and China which are working towards a framework.

2.2.2. Main problem 2: Barriers and uncertainties keep stakeholders from deploying or using C-ITS services

Certain barriers, such as the uncertainties in relation to the cyber security and data privacy of C-ITS communications, and the lack of a clear governance framework for C-ITS, keep stakeholders from the large-scale deployment and use of C-ITS services. This is because they cannot be sure that their implementation can interact with other implementations, or that it will remain in line with evolving rules and practices, especially when requirements differ from Member State to Member State. Addressing these issues is particularly important to move from relatively controlled pre-deployment, with users that are specifically selected and aware of the system, to large-scale deployment, where the system will be available to regular end-users.

2.2.3. Main problem 3: Failure to provide an enabling environment for further C-ITS deployment.

Without the necessary framework to support pre-commercial deployment and an environment that allows the development of attractive business models, C-ITS uptake will be very slow. Network effects that are necessary to access the economic, social and environmental benefits will not be achieved quickly and efficiently, making it difficult for early deployers to justify investments. Considering the many actors involved in the C-ITS value chain, the development of sustainable business models requires coopetition and coordination. Also developments in C-ITS and CCAM need to be coordinated across the EU to ensure that they reinforce each other, rather than taking divergent paths.

2.3. Problem drivers

2.3.1. Problem driver 1: Lack of common definition / priority of C-ITS services

Work carried out by the C-ITS Platform and via existing deployment projects has shown that there is a need for common definitions for C-ITS services. C-ITS technology is rapidly evolving and without common definitions, each stakeholder with the same intention could develop slightly different services, or implement the same service in a slightly different way, risking that the service is neither interoperable nor continuous across the EU, and thus does not reach its full market potential. The C-ITS Platform Phase II report highlighted the need for developing common definitions for C-ITS services to support continuity and interoperability of services across the EU.

Work has already been carried out in the EU on the definition of C-ITS services and harmonized standards and profiles for services and systems. (Note: Standards often give a number of implementation options. Profiles further define how these options should be implemented to ensure an interoperable solution. Both are thus required together to ensure interoperability):

- The ESOs have developed a large set of standards for C-ITS services and systems, in particular following the mandate given by the Commission in 2009.
- The Car2Car Communication Consortium, which includes a large share of EU vehicle manufacturers, as well as technology and research partners, has worked since 2002 on C-ITS, in particular on V2V services. It has developed harmonised service profiles for Day 1 V2V services, as well as a harmonised system profile for in-vehicle C-ITS stations using short-range communication. The latest version was released in August 2018.
- The C-ROADS Platform, which unites 16 Member States and road operators working on interoperable cross-board C-ITS deployment, in particular on V2I services. It has developed harmonised service profiles for Day 1 V2I services, as well as a harmonised system profile for road-side C-ITS stations using short-range communication. The latest version was released in June 2018.

In addition to common definitions of services, prioritisation of mature safety-relevant C-ITS services would also be beneficial (e.g. by providing a focus on the deployment of Day 1 services) to ensure that stakeholders focus first on deploying a set of common C-ITS services, ensuring quicker network effects and reaping higher benefits as a result.

The definition of C-ITS services was supported by the stakeholders interviewed, with most indicating that this should include technical profiling to ensure interoperability across the EU. The C-Roads Platform representative suggested that safety-related services could be prioritised.

2.3.2. Problem driver 2: Uncertainties regarding minimum requirements for interoperability of C-ITS stations (including on communication technologies)

Having common service definitions is not enough to provide continuous C-ITS services. An integrated C-ITS system relies on the interoperability of its components. That means that systems need to be able to interact with each other, across borders and at different layers: applications, facilities, networking & transport, access and security (see Figure 2). This requires open, standardised interfaces and consistent end-to-end security features. Note that this does not require each individual element within a C-ITS station to be interoperable, but rather that C-ITS stations can communicate/understand each other, encouraging innovation and competitive differentiation.

Without any minimum requirements for system interoperability at the EU level, deployment will remain fragmented with limited interoperability and continuity across the EU. As indicated in section 2.3.1, the CAR2CAR Communication Consortium and the C-ROADS platform respectively developed a harmonised system profile for in-vehicle C-ITS stations and road-side C-ITS stations using short-range communication. Work is ongoing in C-ROADS on a harmonised system profile for long-range cellular C-ITS communication.

The creation of technical communications profiles for each technology and for all Day 1 services was recommended by several stakeholders who noted that without clear profiles there will be too much variation in the services deployed and thus no interoperability or continuity of service. However, other stakeholders noted that interoperability requirements should be kept minimal to avoid burdening new technologies.

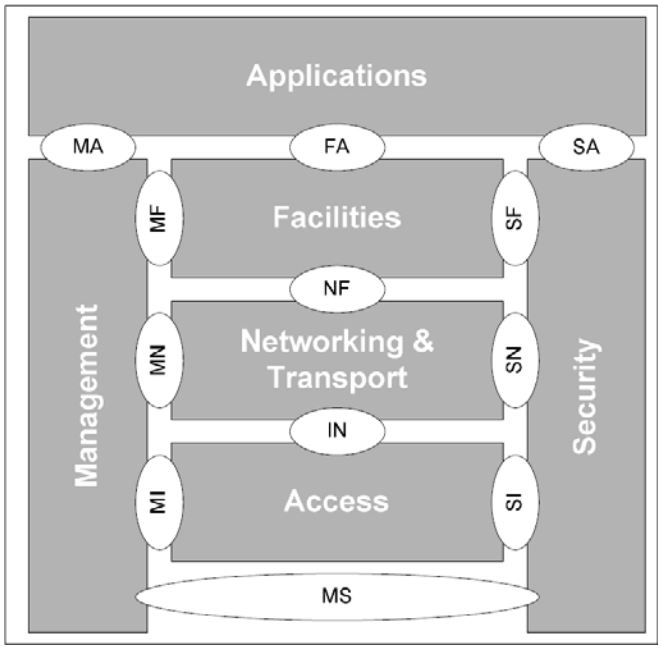


Figure 2: C-ITS station reference architecture (source: EN 303 665)

Communication technologies

A particular important issue for C-ITS are the communication technologies (the access layer in Figure 2) that can be used for delivering C-ITS and how we combine them. This follows directly from the need to ensure everybody is connected to everybody (interoperability), and making sure everybody remains connected to everybody (backwards compatibility).

A first key principle is that – to maximise the benefits of C-ITS and deliver all V2V, V2I and vehicle to everything (V2X) services as efficiently as possible – we need to leverage the distinct advantages of different, complementary technologies. This is the so-called hybrid communication approach and already today combines two types of technologies:

- **Short-range communications technologies** operate in a dedicated 5.9 GHz frequency band. ITS-G5 was developed specifically for this purpose (based on the IEEE 802.11p protocol) and is currently mature, tested and already deployed.

  Short-range technologies are particularly relevant for time-critical services (e.g. warnings of oncoming collisions or other imminent dangers), for instance through the direct

communication between vehicles and other traffic participants, and for direct exchange between vehicles and the infrastructure on busy road segments and intersections.

The efficiency of dedicated roadside units depends strongly on the amount of traffic. Considering that roadside unit enable short-range communication, they generally enable more time-critical services that can delivered better than solely through long-range communication, but at an added cost. Thus the decision to deploy roadside infrastructure is expected to be made on a case-by-case basis by public authorities or road operators.

- **Longer-range communications technologies** leverage the coverage of existing networks and connect large areas,. Mature technologies are cellular 3G/4G, which already provide good coverage in large parts of the Union.

  Long-range technologies are currently particularly relevant for less time-critical services (e.g. in-vehicle signage or routing information).

In other words, the practical implementation of the first principle (complementary technologies), combined with the need to ensure interoperability and continuity of services, implies we have to make technological choices. This should however not hinder further innovation. Therefore, a second key principle is that the system should be, as much as possible, independent of the communication technologies used. This means that future technologies can be integrated more easily in the hybrid communication mix, several candidates exist already:

- LTE-V2X is a cellular-based short-range communication technology that could also enter the market in the next few years. Note: if LTE-V2X and ITS-G5 would both be used to deliver the same services, there is a need to address interoperability (or redundancy) between them. Otherwise, everybody will not be connected to everybody, and accidents could still happen between two equipped vehicles.
- 5G is the next generation cellular network, which could include both a long-range and a short-range 5G-V2X variant. This technology is still under development and is in particular expected to play a role in particular as an enabler for higher levels of automation.

C-ITS technology: an international perspective[34]

In the **EU**, C-ITS is in an early deployment phase, with 16 Member States and several vehicle manufacturers currently deploying based on the hybrid communication approach (a mix of ITS-G5 and 3G/4G). This deployment builds on extensive testing and evaluation in many field trials with many relevant standards already drafted and published. Early tests are ongoing for LTE-V2X.

The **US** is also in an early deployment phase, including three large-scale deployment programs planning the deployment of approx. 10.000 C-ITS devices + a support action for each state to equip at least 20 intersections. In 2016, the US Department of Transportation proposed to equip all vehicles with DSRC short-range communication (equivalent to ITS-G5). DSRC deployment is also supported by a large group of states and industry, but the mandate has since been put on hold by the new administration. Early tests are ongoing for LTE-V2X.

In **Japan**, there is already large-scale deployment of short-range communication similar to ITS-G5/DSRC with some 1,600 roadside units communicating with 2.5 million on-board units fitted to cars for a limited but important set of services.

34 For detailed case studies on deployment projects in the EU, and country case studies on the US, Japan and Australia, please see Annex D of the support study.

China is relatively new in the C-ITS space, but looks to move quickly from testing to early deployment. Its recently adopted smart car strategy[35] puts a strong emphasis on deploying C-ITS on cellular based technologies, both for short (LTE-V2X/5G-V2X) and long range.

Australia positions itself to be an early adopter of C-ITS developments. Considering that Australia has a relatively limited automotive industry, applications deployed in Australia would be based on those applications deployed internationally, at least in the initial deployment period. Given that its automotive standards and radio spectrum allocation resemble those in the EU, Australia considers following European standards for C-ITS deployment as the default option.

Stakeholder feedback on communication technologies

Public consultations

The respondents to the public consultation[36] for the 2016 EU C-ITS strategy gave widespread support for the hybrid communication approach: indeed, less than 5 percent disagreed with initial deployment based on ITS-G5, and the vast majority see LTE-V2X or in future 5G cellular communications playing an important role in the long-term. In the 2017 Public Consultation, a strong majority considered that it was important to achieve the objective of interoperability and a forward-looking hybrid communication approach at EU level, but respondents were more split on how this should be achieved.

A vehicle and equipment manufacturer called for 'co-existence concepts' for ITS-G5 and LTE-V2X to be developed. An ITS service provider noted that a hybrid communication approach was essential, particularly as short-range broadcasting might not be the best technology for all use cases. Some stakeholders had reservations around requiring interoperability between technologies in a hybrid approach. A vehicle manufacturer called for the hybrid communication approach to allow for both Wi-Fi and C-V2X, despite noting that interoperability between these was not possible at this stage. A vehicle and equipment manufacturer noted that clarifying the role of these two communication technologies was important, as there should not be competing technologies from the first day.

Amongst the stakeholders interviewed for the case studies there was consensus that interoperability is essential for an effective C-ITS system, allowing all vehicles to communicate with each other, but allowing for flexibility of technologies to be chosen. A C-Roads Platform position paper on the use of the 5.9 GHz band of the radio frequency spectrum[37] was submitted which underlined that there should be interoperability between ITS-G5 and LTE-V2X and that road authorities should not be forced to equip their roads with two or more competing technologies. Additionally, it stated that the platform's members were committed to 'backwards compatibility' criteria.

On the other hand, an association representing telecommunications interests (and a similar response from a private company) noted that no technology should be seen as the incumbent; instead the choice should be based on cost-efficiency. They believed it preferential that both

35 http://www.ndrc.gov.cn/yjzq/201801/t20180105_873146.html

36 Report on the analysis of responses: https://ec.europa.eu/transport/sites/transport/files/2016-c-its-deployment-study-public-consultation.pdf

37 C-Roads Platform (no date) "Radio frequencies designated for enhanced road safety in Europe - C-Roads position on the usage of the 5.9 GHz band"

LTE-V2X and ITS-G5 co-exist and compete for the same services in the 5.9 GHz radio spectrum frequency band. They also considered that LTE-V2X should not be required to be interoperable and backwards compatible with ITS-G5.

A technology supplier, on the other hand, was critical of the 'push from the cellular industry' to bring an unproven technology into the same radio spectrum frequency band in which stakeholders were already deploying ITS-G5, and was concerned that this would affect the deployment of the latter and so not deliver its potential benefits. A vehicle manufacturer noted that feasibility tests are needed to be undertaken on the potential of LTE-V2X to co-exist with ITS-G5 in the 5.9 GHz frequency band.

Further consultations

Throughout the Impact Assessment process, several bilateral consultations with representatives from the automotive industry, technology suppliers, telecommunications industry and MS experts have been held, as well as a number of position papers and letters have been received, with particular emphasis on communication technologies. These largely reflect a similar divergence of opinions, with clear support from some stakeholder groups on clear rules for interoperability starting from mature implementations, while others argued for a technological-neutral framework where the choice of technology is left to the market.

In discussions with MS experts, some MS argued for a technological-neutral framework where the choice of technology is left to the market, but a strong majority agreed with the need for clear EU rules for interoperability, starting from mature implementations available now, and including a clear and transparent path for the inclusion of future solutions and technologies.

2.3.3. Problem driver 3: Barriers to establishing the necessary trust with regard to cyber security of C-ITS communications

As the transport system becomes more and more digitised, it may also become more vulnerable to hacking and cyber-attacks. Secure and trusted communication of messages exchanged between vehicles and infrastructure will therefore be key for the successful deployment of C-ITS services, so users can be sure the message is correct and sent by a trusted source, and that the information they send is sufficiently protected. Both operators and users will need to trust the cyber security of C-ITS communications, otherwise they will refrain from using it, providing a barrier for large-scale deployment.

The C-ITS Platform concluded that cyber security is still a barrier for the deployment of Day 1 C-ITS services in Europe. Without clear rules, adopted at the EU level, the development of security solutions will be fragmented and could put interoperability (see Figure 2) and the safety of end-users at risk.

The Phase I report of the C-ITS Platform included a very detailed analysis of the different options for the implementation of a trust model to ensure secure and interoperable exchange of C-ITS messages on across the EU. As an outcome of this process, Member States and industry representatives consensually agreed on the need for a set of common EU technical and organisational requirements.

In Phase II of the C-ITS platform, stakeholder worked together and agreed on the definition of a European Union C-ITS Security Credential Management System (EU CCMS) for C-ITS

messages. The EU CCMS is described in two important documents[38] to enable secure and interoperable C-ITS Day 1 Service deployment in the EU:

- C-ITS Certificate Policy for Deployment and Operation of European C-ITS, which was published in June 2017. An update release 1.1 was agreed in June 2018.
- Security Policy & Governance Framework for Deployment and Operation of European C-ITS, published in December 2017.

2.3.4. Problem driver 4: Uncertainties regarding to minimum requirements for compliance assessment of C-ITS services

To ensure that C-ITS services function in a seamless way, it should be checked if C-ITS services and different types of C-ITS stations comply with service and system requirements. Otherwise non-functioning and potential damaging services and systems could be introduced, putting in jeopardy the reliability and trustworthiness of the entire C-ITS system.

Thus an effective compliance assessment framework needs to be set up that allows C-ITS services and different types of C-ITS stations to be checked against EU-wide system requirements. The C-ITS Platform Phase II report highlights the need for a common EU legal and technical framework to implement the proposed roles, requirements and processes for compliance assessment. Currently such a framework does not yet exist.

2.3.5. Problem driver 5: Uncertainty on how to comply with rules on privacy and protection of personal data

Data sent in C-ITS messages is already minimized and pseunodimised for technical and data protection reasons. Nevertheless, data sent in C-ITS messages from vehicles still qualifies as personal data - as data can be directly linked to the vehicle and indirectly to the identity of the vehicle owner - and is therefore related to an identified or identifiable natural person[39]. The risk of tracking individuals has been recognised as a particular issue that could hamper trust in C-ITS, and could lead to end-users and other stakeholders refraining from using or providing C-ITS, limiting its deployment.

From the perspective of the consumer, respondents in the 2016 Public Consultation were asked if they would give consent to allow C-ITS stations to broadcast their data and under which conditions. The responses received indicate that consent to broadcast data is not an overwhelming barrier among the participating stakeholders when:

- The data is being used only for C-ITS services (58% of respondents)
- To enhance safety (67%) or reduce congestion (64%)
- If the user has control at all stages over the sharing of his/ her data (39%), with some respondents caveating their support based on adequate safeguards being in place, and some indicating that different rules should apply according to the end use of the data.

Any successful C-ITS deployment must be compliant with the applicable legal framework for data protection (including the General Data Protection Regulation (GDPR - Regulation 2016/679) and, where applicable, the ePrivacy Directive (Directive 2002/58)[40] to increase trust

38 Available at: https://ec.europa.eu/transport/themes/its/c-its_en

39 See Annex 6 for more detail on the use and protection of personal data in C-ITS.

40 A proposal for the revision of the ePrivacy in currently being negotiated.

among users. Data protection by design and data protection impact assessments are of central importance in basic C-ITS system layouts and engineering, especially in the context of the applied communication security scheme.

There is uncertainty among stakeholders on how they can comply with data protection requirements and what legal basis for lawfully processing personal data they can use in the context of C-ITS, given that it is a novel way of information exchange. Some stakeholders also fear that the data protection requirements might be applied differently across MS, hindering the efficient provision of EU-wide services, as these might need to be adjusted between MS.

Thus, stakeholders noted that the GDPR will require some of the previous work in this area to be rethought. There needs to be a clear understanding on how to comply with rules on privacy and protection of personal data, especially for safety-related applications where benefits cannot be generated unless the data is shared.

While both these concerns demand attention, it is important to remind that within the framework of the GDPR a number of mechanisms exist to ensure the consistent application of the data protection rules:

- First, it has to be recalled that the application of GDPR is based on the principle of accountability. Data controllers are responsible to implement the appropriate technical and organisational measures to ensure and be able to demonstrate that processing is performed in accordance with the GDPR.
- Second, the GDPR contains mechanisms to ensure a consistent approach by the data protection authorities on the application of the data protection rules within the EU (such as one-stop-shop and consistency mechanisms).
- Third, the European Data Protection Board has issued a number of guidelines, and will continue to issue guidelines where needed, to ensure a consistent application of GDPR.

In both phases of the C-ITS Platform, a dedicated working group analysed subject of data protection in C-ITS. The focus of the analysis in Phase II was on C-ITS Day 1 use cases in the context processing personal data in accordance with Article 5 of the GDPR. The analysis found that there currently is no law that justifies the processing of personal data for C-ITS, but a mix of contractual obligations between the Data Subject and the Data Controller and between the Data Controllers themselves could be an appropriate legal basis.

The working group then submitted their findings to the representative of the technology subgroup of Article 29 Working Party on the 10th of July 2017. An opinion was received in October 2017[41], which indicates a number of actions required to support the lawful processing of personal data in the field of C-ITS.

2.3.6. Problem driver 6: Lack of coordination between relevant bodies

As discussed before, a wide range of stakeholders is involved in C-ITS, spanning across different means of road transport, the public sector and different industries, as well as local, regional, national and EU-level actors. With technology rapidly evolving and the public and private sector investing substantial amounts into developing and testing C-ITS technologies, there is a risk that, without adequate coordination, solutions will be developed in a fragmented and inefficient

41 Article 29 Working Party Opinion 03/2017 on processing personal data in the context of Cooperative Intelligent Transport Systems (C-ITS, available at: http://ec.europa.eu/newsroom/article29/item-detail.cfm?item_id=610171

manner. In addition, this means risking that C-ITS do not function as they should, responsibilities for different parts of the system remain unclear, and smaller actors (local/regional authorities, SMEs) cannot get involved.

A lack of coordination across the EU could also hinder the necessary synergies between C-ITS and CCAM, as efforts could be duplicated or contrary to each other. The C-ITS Platform Phase II report identified the need for the European Commission to take enabling actions in order to assist Member States and other stakeholders in implementing C-ITS services and to coordinate this closely with CCAM activities.

Once deployment starts, there is also the need to support harmonized and synchronized implementation through increased cooperation between both public and private actors. Other complex telematics applications in other transport modes have shown the benefits of an effective governance in the implementation phase of such initiatives. Different levels of coordination should be considered to ensure:

- overall governance and supervision
- implementation and update of common specifications
- coordination of operational tasks

Stakeholders noted that the C-Roads Platform already provides some level of coordination and governance regarding deployment activities, but that further coordination is required at the EU level.

2.3.7. Problem driver 7: Uncertainty about business models

The C-ITS market is not yet a mature market and across the EU, uncertainties exist around how sustainable business models for different stakeholders can be developed. This must be addressed to ensure public acceptance and widespread deployment. While the cost benefit analysis carried out for the 2016 C-ITS Deployment study has already shown that the potential benefits of C-ITS strongly outweigh the costs, these benefits will only materialise over time and depend strongly on coordinated and accelerated deployment.

Part of the issue is that a large part of these C-ITS benefits (increased safety, less time spent in traffic, lower fuel consumption) go directly to the users / society at large, while the costs of investment and operation need to be borne upfront by road operators and vehicle manufacturers. Moreover, the possibility to pass these costs on to users might be limited given the public nature of (some of) the benefits.

On the other hand, several stakeholders have additional incentives to deploy C-ITS which also have to be considered. Car manufacturers are continuously integrating new safety measures in vehicles, and C-ITS can be seen as the natural supplement of camera or radar based Advanced driver-assistance systems (not suffering from line-of-sight limitations and giving earlier warnings). A second reason is the potential of C-ITS to support and enable higher levels of automation. A third reason is that car manufacturers are also becoming service providers, and for vehicles to become a new service platform they need to be connected.

For telecommunication companies there is the potential to provide new services, connections and equipment to generate new revenue streams from connected vehicles. For public transport, the current set of services already includes the possibility to prioritize public transport at

intersections, and work is being done to develop C-ITS services for rail intersections, increasing their safety.

As the deployment of C-ITS cannot rely on public funding alone and requires the involvement of stakeholders from different industries and the public sector, a common understanding of business models for deploying C-ITS, and their integration into broader CCAM functionalities, is needed. It is particularly important to ensure that there is a level playing field, which enables the development of attractive business models from a range of potential market actors.

The need for a clearly identified business model was further highlighted during stakeholder interviews. A representative from the C-Roads Platform considered the lack of a common business models for all stakeholders (manufacturers, service providers, authorities, and road operators) as the most important issue preventing C-ITS deployment. They noted that each group involved in deployment has to trust the others to deploy, or risk stranded investments. A representative from C-Roads France also noted that a lack of trust between stakeholders slows deployment, as each stakeholder is waiting for the other to deploy before they invest.

2.4. Most affected stakeholders

If C-ITS services are not deployed to their full potential, important positive impacts on road safety and traffic efficiency will not be achieved. This affects all road users, as road fatalities and serious injuries create suffering for those involved in the accidents and low traffic efficiency leads to significant time lost in traffic and associated increased CO_2 and pollutant emissions. In addition, they create costs that are ultimately borne by society as a whole, including the costs of emergency services, health care costs and production losses. It will also be detrimental to road operators and traffic managers, who will have less access to new solutions which allow them to more efficiently manage their networks.

Delays to C-ITS deployment would put the European automotive and ITS industry at a disadvantage compared to its competitors, leading to lower levels of new business opportunities in the digitalisation of transport along with lower levels of job creation, and less significant research and innovation impacts on the overall European economy. As the jobs of millions of Europeans depend directly or indirectly on the automotive and wider transport industries, it is critical that the sector is provided with the conditions to keep up with global market players.

The telecom sector is also affected as C-ITS and CCAM services can use their cellular network and technologies to deliver services and this can thus constitute a new growth market.

2.5. How will the problem evolve?

If no action is taken, only 18% of the vehicle fleet is expected to be equipped with C-ITS by 2035, as stakeholder will not have the necessary certainty on the continuity and interoperability of C-ITS services to move to large-scale deployment. This expectation is based on literature review, expert judgement and stakeholder consultation and considered existing activities and industry announcements.[42]

As a result the total number of accidents in the EU is expected to decrease from 1.46 million in 2015, to 1.35 million in 2030 and 1.30 million in 2035. While this is an improvement, it is not enough to reach the EU's long-term goal of moving close to zero fatalities and serious injuries by

42 More details on the establishment of the baseline can be found in the support study.

2050 (“Vision Zero”), with an interim target for serious injuries of minus 50% between 2020 and 2030.

Congested roads remain a huge issue in the baseline, with urban travel time costs in the EU expected to increase from €548.6 billion annually, to €618.5 billion annually in 2030 and €627.2 billion annually in 2035.

While emissions of CO_2 and air pollutants are expected to decrease, road transport will remain a main source of these emissions, with annual CO_2 emissions projected to decrease by 13 percent in 2030 and 15 percent in 2035 compared to 2015[43]. The NOx emissions are expected to decrease by 53 percent during 2015-2030 (60 percent for 2015-2035) while the PM emissions would go down by 38 percent during 2015-2030 (39 percent for 2015-2035) and VOC would decrease by 25 percent during 2015-2030 (24 percent for 2015-2035).

Note that the baseline for this impact assessment, assessed with the ASTRA/TRUST models, builds on the updated 2016 EU Reference scenario used in the impact assessments accompanying the new General Safety Regulation and Road Infrastructure Safety Management Directive proposals (GSR/RISM), but includes additional policy measures and initiatives related to C-ITS. The baseline scenario therefore assumes the application of the current GSR/RISM, as required by the Better Regulation principles.

There is little overlap between the technologies considered in the GSR/RISM baseline and the C-ITS services considered in this study, however there are some overlapping impacts. This is due to the overlapping effects between the impacts of the policies, in the same way as there is nearly always more than one factor in accident causation. Thus, the combined effect of improved road infrastructure, increased vehicle safety and C-ITS measures deployed together is going to be somewhat lower than the sum of their individual effects. In the GSR Impact Assessment, accidents (the only impact modelled) reduce by 7-8 percent in the policy options. To account for the overlap in impacts, we have reduced the benefits of C-ITS services on safety by 10 percent[44] across all C-ITS services in the baseline and policy options modelled.

3. WHY SHOULD THE EU ACT?

3.1. Legal basis

The Union has shared competence in the field of transport as set out in Article 4 of the TFEU. The ITS Directive is based on Article 91 of the TFEU. Article 6(3) of the ITS Directive requires the Commission to adopt specifications ensuring compatibility, interoperability and continuity for the deployment and operational use of ITS for other actions in the priority areas, including action 4.1.2: The definition of necessary measures to further progress the development and implementation of cooperative (vehicle-vehicle, vehicle-infrastructure, infrastructure-infrastructure) systems.

43 The Baseline scenario developed for this impact assessment does not reflect the recent initiatives proposed by the Commission that have a direct impact on CO2 emissions (e.g. CO2 standards for new light duty vehicles for 2030, CO2 standards for heavy goods vehicles for 2030, revision of the Clean Vehicles Directive, etc.)

44 Compared to the benefits originally determined for C-ITS services in the support study. This reduction applies to all modelling scenarios, and is separate from the sensitivity analysis in Section 6.4.

3.2. Subsidiarity: Necessity of EU action

While C-ITS services are currently already being deployed through projects across the EU, and several Member States and a large number of vehicle manufacturers have already indicated their intention to move to large-scale deployment, many of them have indicated that a legal framework at the EU level is needed. Industry-led standardisation through the ESOs contributes to interoperability, but it is voluntary by nature and can allow for different, non-interoperable implementations, and with some many different actors and strong network effects, no actor can introduce an interoperable solution on its own. This was already recognized in the 2009 standardisation mandate, which indicated that to ensure EU-wide interoperability, essential parts of the standards would need legal enforcement measures. Similarly, setting rules at the national level would likely hinder the provision of continuous C-ITS services in the Single European Transport Area.

Compatibility between infrastructure and vehicle solutions will need to be assured across the EU in order to fully benefit from C-ITS. In addition, to ensure effective synergies with the deployment of new safety technologies and the roll-out of CCAM across the EU a more harmonised approach at EU level is likely needed.

The business case for C-ITS being difficult as it is, no vehicle manufacturers would consider deploying in a small market. Only when reassurance is given that harmonisation is achieved at EU level, implying also, crucially, that vehicles will benefit from infrastructure services all across the Union, does deployment make sense. Similarly, though the business case is calculated differently for the public sector, it makes no sense to invest unless large portions of the fleet are expected to be equipped in the near future.

Thus, without an EU level framework, deployment is expected to remain fragmented and uncoordinated and cannot provide geographical continuity of C-ITS services throughout the Union and at its external borders.

3.3. Subsidiarity: Added value of EU action

The main benefits of EU action lie in the continuous C-ITS services across the EU which the initiative aims to achieve. Travel throughout the EU should become safer and more efficient, whereby less advanced Member States will be able to benefit from the experience of more advanced Member States. This should in turn improve the functioning of the internal market, through a smoother and more coherent travel experience for passenger and freight transport, and support the EU's objective of economic, social and territorial cohesion.

A framework for continuous C-ITS services, supported by a broad group of stakeholders, would also help create a supportive ecosystem for the research and innovation in new C-ITS services and technologies, and the introduction of CCAM in the EU, improving the EU’s international competitiveness in this field.

4. OBJECTIVES: WHAT IS TO BE ACHIEVED?

4.1. General objectives

This initiative aims to establish a clear framework to support interoperable deployment, by the private and public sector, and uptake of C-ITS services across the EU.

This should help increase the continuity of C-ITS services across the EU, which in turn will help significantly improve road safety and traffic efficiency. It should further improve the contribution from the transport sector to the reduction of CO_2 and air pollutant emissions and contribute to competitiveness and growth. In addition, the availability of interoperable and continuous C-ITS services will also serve as a crucial step for the deployment of CCAM.

4.2. Specific objectives

To achieve this general objective, three specific objectives have been defined:

SO1: to ensure interoperability and continuity of C-ITS services across the EU.

SO2: to reduce barriers and uncertainties to enable large-scale deployment of C-ITS.

SO3: to provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models.

These specific objectives are directly linked to the main problems identified in section 2. Overall, there are strong synergies between the objectives. Ensuring interoperability and continuity, and removing uncertainties, will give stakeholders certainty that when they invest in C-ITS equipment or the deployment or development of new C-ITS services, there is a readily available sustainable eco-system with many users across the EU supported by a clear operational framework, which will make the development of attractive business models much more likely. On the other hand, the design of the measures has to be such that they ensure a common approach, but also support and not needlessly restrict innovation, in line with the principles for specifications and deployment of ITS set out in Annex II of the ITS Directive.

5. WHAT ARE THE AVAILABLE POLICY OPTIONS?

Based on the impact assessment support study and on contacts with stakeholders (through targeted consultations, the open public consultation, and meetings), the Commission has identified a number of policy measures in line with the specific objectives of the initiative, to address the main problem drivers as listed above.

These policy measures have been combined into policy packages (options). In the development of the policy options, the principles of proportionality, efficiency and effectiveness have been the guiding principles.

5.1. Description of the retained policy measures

Based on literature research and stakeholder input, a long list of policy measures was developed. To help identify and prioritise which measures from the long list should be retained, a scoring system based on a Multi Criteria Analysis (MCA) framework was used.[45] For each of the measures the following criteria were assessed: Technical feasibility, Legal feasibility, Societal acceptance, Effectiveness, Efficiency, Proportionality, Relevance and EU added value.

After this preliminary assessment, 22 policy measures were retained. The retained policy measures are presented below organised according to the main problem driver that they aim to address.

45 See section 4.2 of the support study for more details.

Problem driver 1: Lack of common definition / priority of C-ITS services

No.	Policy measures and policy measure description
1	**Non-binding guidelines to support the provision of interoperable Day 1 services** The Commission would publish non-binding guidelines on its website on the basis of existing standards on interoperability and EU-wide service profiles[46] and system profiles[47] (such as those published by CAR2CAR and C-ROADS).
2	**Definition of Day 1 services and their profiles in binding specifications + requirement for other services to be compatible with all Day 1 services** The Commission would define a list of Day 1 services and require that when these are implemented they are implemented according to their service profile, to ensure that they can always be interpreted in the same way. Other services have to be compatible with the day 1 services, to ensure that they do not interfere (e.g. by not using the same data elements for different purposes) with the provision of Day 1 services.

Problem driver 2: Uncertainties regarding minimum requirements for interoperability of C-ITS stations (including on communication technologies)

No.	Policy measures and policy measure description
3	**Mandate compliance with EU-wide system profiles in specifications** The Commission would define types of C-ITS stations and their system profiles, and require that C-ITS stations are implemented according to their system profile, to ensure that they can communicate in an interoperable and compatible way. C-ITS stations have to be compatible with the day 1 services, to ensure that they do not interfere with the provision of Day 1 services. At this stage, the system profiles would be based on the current hybrid approach, combining mature 3G/4G and ITS-G5 technology. At the same time the integration of future technologies is foreseen through a review clause to integrate interoperable and complementary solutions.
4	**Mandate to EU level standardisation organisations for further standardization.** The Commission would give an updated mandate to the European Standardisation Organisations to further the standardisation of C-ITS stations and services to improve interoperability, including the integration of new types of stations, services, and technologies.
5	**Mandatory deployment of V2V communication** The Commission would mandate vehicle manufacturers to fit all new vehicles with C-ITS stations to deliver (a number of) Day 1 C-ITS services. This measure would come on top of specifications in a delegated act, for instance through a revision of the General Safety Regulation[48] or a separate legal instrument (similar to the eCall approach). This would ensure all new vehicles are capable of delivering and receiving C-ITS messages, strongly increasing the continuity of C-ITS services across the EU.

Problem driver 3: Barriers to establishing the necessary trust with regard to cyber security of C-ITS communications

No.	Policy measures and policy measure description
6	**Non-binding guidelines on the European Union C-ITS Security Credential Management System (EU CCMS)** The Commission would publish non-binding guidelines on its website based on existing published documents (the Certificate Policy (CP) & Security Policy (SP)). Participants in the C-ITS network in Europe would need to adhere to these documents, however it would not be legally binding.
7	**Binding rules on the European Union C-ITS Security Credential Management System (EU CCMS)** The Commission would adopt binding specifications on the EU CCMS, ensuring the participants in

46 Detailed specification of the purpose of the service and the content & triggering conditions for the message to be sent.

47 Detailed specification of how the system should be designed and operated, specifying settings of parameters defined in standards.

48 The impact assessment for the May 2018 proposal for a revision of the GSR (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018SC0190&from=EN , Annex 11) considered including C-ITS in the scope, but discarded it as the standards and specifications were not available at the time, and that work should first be carried forward.

	the C-ITS network in Europe fulfil the requirements of the common trust model and that one common interoperable security solution is used, by requiring that every C-ITS station is enrolled in the EU CCMS This would also include a review clause based on security assessment and technological progress.

Problem driver 4: Uncertainties regarding minimum requirements for compliance assessment of C-ITS services

No.	Policy measures and policy measure description
8	**Non-binding guidelines on the compliance assessment process for Day 1 C-ITS services** The Commission would adopt guidelines on the compliance assessment process. It will recommend Member States and other stakeholders to check compliance against the specifications but follow-up actions are not specified and this cannot serve to "approve" C-ITS stations.
9	**Definition of compliance assessment criteria for Day 1 C-ITS services + conformity assessment procedure based on internal production control** The Commission would introduce binding specifications on the compliance assessment process. The conformity assessment procedure would be based on internal production control, i.e. the manufacturer checks the conformity of a C-ITS station during both the design and production phase.
10	**Definition of compliance assessment criteria for Day 1 C-ITS services + conformity assessment procedure based on external conformity assessment** The Commission would introduce binding specifications on the compliance assessment process. However, in contrast with measure 9, the conformity assessment would be carried out by an external conformity assessment body, ensuring that the assessment is both impartial and independent. This measure would require a legal instrument through co-decision.

Problem driver 5: Uncertainty on how to comply with rules on privacy and protection of personal data

No.	Policy measures and policy measure description
11	**Non-binding guidance on the processing of personal data in the context of C-ITS** Building on the opinions and guidelines of the European Data Protection Board, the Commission would publish non-binding guidance on the processing of personal data in the context of C-ITS (underlining the roles and responsibilities of actors, and the requirements applicable to them under GDPR). In addition the Commission would do a state-of-play of what C-ITS actors do/have done in respect of privacy and data protection (including data protection impact assessments).
12	**Define the purposes for lawfully processing personal data as traffic safety & efficiency, restricting other uses.** The Commission would introduce binding specifications identifying the purposes for lawfully processing personal data in the context of C-ITS as traffic safety and efficiency, while restricting the use of personal data for other purposes. All these specifications should be without prejudice to the General Data Protection Regulation.
13	**Introducing a legal basis for the lawful processing of personal data in C-ITS** The introduction of a legal instrument through co-decision (i.e. on top of specifications in a delegated act, for instance through the V2V mandate (measure 6)) can introduce a legal ground for the processing of personal data related to C-ITS, which would clarify the reasons and simplify the approach to processing C-ITS messages.

Problem driver 6: Lack of coordination between relevant bodies

No.	Policy measures and policy measure description
14	**Coordination and Policy Advice through stakeholder platform** The Commission would set-up a cooperative framework including national authorities and C-ITS stakeholders in the form of a Commission Expert Group, in view to further develop a shared vision and guidance on the interoperable deployment of C-ITS in the EU. This would improve knowledge sharing and cooperation, similar to what was done in the C-ITS platform.
15	**Enhanced deployment coordination** This would be a more elaborate coordination structure than policy measure 14, including the coordination of deployment projects (such as is currently done in C-ROADS) and the implementation and preparation of revisions of the delegated act.

	This will ensure that lessons learnt will be shared across projects. This will help follower countries to access lessons learned from front runner countries and accelerate their uptake. Coordination of deployment will also help ensure that the most effective services are deployed in a similar manner.
16	**Non-binding guidelines on governance framework/bodies** To implement C-ITS, a governance framework with several bodies with clearly defined roles is needed, for instance for implementing the security and certificate policy and the compliance assessment process. This will also contribute to improve coordination and cooperation across the EU. Non-binding guidelines would identify the needed bodies, their roles and the tasks to be carried out, building on the work on the governance framework already carried out under the C-ITS platform and published in the security policy. Non-binding guidelines would however not ensure that all necessary bodies are set up, operating in the expected way or recognized by all stakeholders.
17	**Definition of needed roles in specifications + requirement to report to the Commission on the bodies/authorities in charge.** Instead of the non-binding guidelines in measure 16, the roles and tasks would be defined in legally binding specifications and MS and/or stakeholders setting up these bodies would be required to report this to the Commission. This will increase transparency and public knowledge, however it would still not ensure that all necessary bodies are set-up.
18	**Definition of needed roles in EU law + Assignment of roles to legal bodies** This measure would require that all roles and tasks in the governance framework are assigned and carried out by new or existing legal bodies (e.g. the governance body, supervision body and the security & certificate policy authorities foreseen in the governance framework of the Security Policy). In this way it can be ensured that all essential tasks for managing the C-ITS network in Europe are carried out, and in case of the set-up of European-wide bodies, efficiency gains could be achieved. This measure requires a legal instrument through co-decision.

Problem driver 7: Uncertainty about business models and integration in CCAM

No.	Policy measures and policy measure description
19	**Memorandum of Understanding (MoU) between key stakeholders** The EU could support MoUs between key stakeholders to set deployment strategies and targets, given that some MoUs in the area of C-ITS already exist (e.g. between C-Roads and the Car2Car Communication Consortium, and in the context of the letter of intent for CCAM). This would support coordinated deployment. However, as MoUs are non-binding agreements, actual deployment is uncertain.
20	**Funding for development of services beyond the Day 1 list** The Commission would support the development of new future C-ITS services, with an increased focus on services for VRUs and public transport, and the link with CCAM through the continuation of research funding. This would contribute to continued technological development focusing on EU policy objectives.
21	**Funding of deployment based on specifications to enable quicker uptake, including requirement on data reporting and sharing for deployment projects** Funding would be provided for the coordinated deployment of mature C-ITS services and equipment based on common specifications to support continuity of services. Funding would be linked to data reporting and sharing obligations (for instance building on the current collaboration between C-ROADS projects, not sharing sensitive business information), to improve monitoring and knowledge sharing.

5.2. Measures discarded at an early stage

The policy measures that were included in the preliminary analysis but were later discarded are presented below providing also the reasons for discarding them.

No.	Policy measures and policy measure description	Reason for discarding
N1	Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive)	This measure would require C-ITS stations to operate only using mature and proven communication technologies. This would provide added certainty of the interoperability between C-ITS stations, however it would unnecessarily restrict technological development, and less stringent measures have been included.
N2	Requirement for repository of digital Traffic Management Plans and Traffic Circulation Plans, to be available via National Access Points	The topic of traffic management is relevant for C-ITS, but not directly covered by Day 1 C-ITS services. These measures could be reconsidered/developed under the stakeholder platform. Separate measures on this topic are discarded.
N3	Develop building blocks for digital Traffic Management Plans and Traffic Circulation Plans and the deployment of Cooperative Incident Management	The topic of traffic management is relevant for C-ITS, but not directly covered by Day 1 C-ITS services. These measures could be reconsidered/developed under the stakeholder platform. Separate measures on this topic are discarded.
N4	Human-machine interface functionalities for safety time-critical situations should be harmonised: pictogram formats, colours or positions, auditory warning sounds, haptic warnings.	Very relevant for the functioning of C-ITS, but not within the scope of interoperability of V2V-V2I messaging (thus context, rather than measure in this initiative).
N5	Inclusion of C-ITS stations in EuroNCAP rating	Including C-ITS services in the European New Car Assessment Programme would provide consumers with information on the safety benefits of C-ITS and increase acceptance which could lead to higher demand and thus consumer driven uptake. However, this is an industry action which is not in the remit of the Commission.
N6	Binding application specifications for the GDPR in the context of C-ITS, including the responsibilities and requirements	The possibility of adding binding application specifications is very limited, as the GDPR should not be interpreted through other legislation. Relevant aspects of this measure have been integrated in measure 15.

5.3. Description of the policy options

The retained policy measures were combined into three policy options (PO) (in addition to the baseline scenario (Policy Option 0)), which address all policy objectives and problem drivers, but with different levels of ambition. The precise measures and level of ambition of each policy option are described below.

All policy options are compared to the baseline scenario (Policy option 0). Due to the complementary nature of the measures, Options 1 to 3 are alternatives, but build on one another in an incremental way.

5.3.1. PO0: Baseline scenario

Policy option 0 reflects developments under current trends and adopted policies (i.e. the baseline scenario) as described in section 2.5. No further action at EU level is assumed in policy option 0.

As the Commission has a legal obligation to adopt specifications on cooperative systems (in line with Article 6(3) and Annex I of the ITS Directive), the baseline is not a valid policy option but serves for comparative purposes only.

5.3.2. PO1: Light intervention based on non-legislative measures

PO 1 covers minimum change at minimum cost, including non-legislative, "soft" measures which are relatively easy and quick to implement. It builds on the baseline scenario and includes non-binding guidelines on the interoperability of Day 1 services, secure communication, data protection and compliance assessment. Continued technological development is supported by continued R&I funding for the development of new C-ITS services and a renewed standardisation mandate to the ESOs. Coordination between the stakeholders at the EU-level would be a continuation of the informal C-ITS platform.

While this option does not provide the legal framework foreseen in the C-ITS Strategy, and thus will be less effective in achieving the objectives, this option is retained in the analysis, as in the consultations, there was broad support for non-legislative measures as proposed in this option. At the same time a large share of respondents acknowledged that non-legislative measures would only have a limited effect on addressing the problem drivers and thus the deployment and interoperability of C-ITS, and considered more binding measures would be more effective.

5.3.3. PO2: Moderate intervention based on specifications under the ITS Directive

This policy option is based around legally binding specifications through a delegated act. It is a more stringent option than PO 1, to ensure that C-ITS services deployed in line with these specifications are interoperable across the EU. Nevertheless, Member States and industry retain the free choice to deploy C-ITS. To achieve this, it would in particular require all C-ITS stations to be based on, or compatible with, the current hybrid approach, combining mature 3G/4G and ITS-G5 technology (measure 3) and to be part of the common trust model (measure 7). The integration of future solutions and technologies would be foreseen through a review process, which can introduce updated standards and specifications including new technologies and services. To stimulate the continuity of C-ITS services across the EU, deployment coordination and funding is reinforced at the EU level.

In the public consultation, legally binding specifications were seen by the largest group of respondents to be most appropriate to achieve the objectives, but at the same time many respondents also indicated it as the least appropriate for some objectives. This difference was also reflected in the comments that indicated a need for further clarification of how the measures would exactly work and to ensure that legal measures are proportionate. Important splits could be seen in relation to security where many stakeholder groups preferred binding specifications, but ITS service providers preferred an industry-led approach and in relation to interoperability, where many also preferred binding specifications, but none of the ITS service and telecommunications providers. This is to be expected, as ITS service providers do not want the specifications to restrict other ITS services, and telecommunications providers intend to introduce competing C-ITS technology.

5.3.4. PO3: Strong intervention based on V2V mandate + set-up of governance bodies

This policy option builds further on the legally binding specifications of PO2, by adding a V2V mandate to ensure that all new vehicles will be equipped with C-ITS stations, drastically increasing the uptake rate and thus meeting the threshold for effective service delivery – related to the network effect – much quicker.

As the V2V mandate would require a legislative measure, this policy option also includes additional measures that support the deployment of C-ITS and which cannot be introduced through a delegated act alone:

- The introduction of a legislative measure can introduce a legal ground for the lawful processing of personal data related to C-ITS. This will likely result in the provision of more C-ITS services, by reducing the uncertainty for stakeholders.
- The assignment of governance roles to legal bodies will further ensure coordination and oversight on C-ITS deployment, thus ensuring that barriers to C-ITS uptake are reduced to a minimum.

This option would follow the step-wise approach foreseen in the ITS Directive, in which specifications can be followed-up by a separate proposal for deployment. This also ensures that the scope of the system is clearly defined through specifications, before the implications of deployment are considered in more detail. It is important to note, that this second step is not part of the current initiative, and would require a separate proposal accompanied by an additional impact assessment.

Mandatory deployment of V2V communication will significantly increase overall C-ITS deployment. High levels of uptake of V2V services are also expected to trigger enhanced C-ITS infrastructure deployment, because the guaranteed uptake in vehicles will increase the certainty and attractiveness of infrastructure investments.

When asked if C-ITS equipment should be mandated in vehicles and/or on different parts of the road network to accelerate deployment, respondents were moderately favourable (45-64% (strongly) agreed), with many respondents indicating that mandates would provide the needed certainty about deployment, but specific circumstances and the maturity of the system should be reconsidered before defining mandates. Some respondents also noted that mandating deployment can be difficult given the pace of technological change in the industry, and the lack of agreement on which communications technology to use.

Stakeholders interviewed for the deployment case studies were supportive of the establishment of EU governance, policy and operational bodies, as this was considered important in coordinating deployment across Europe. They largely felt that the C-Roads Platform is helping in this regard, but as deployment continues this will need to be further formalised.

Table 1: Linking policy measures to policy options

No.	Measure	PO1	PO2	PO3	Problem driver addressed	Specific objective addressed
1	Non-binding guidelines to support the provision of interoperable Day 1 services	x			D1/2	SO1/2
2	Definition of Day 1 services and their profiles in binding specifications + requirement for other services to be compatible with all Day 1 services		x	x	D1/2	SO1/2
3	Mandate compliance with EU-wide system profiles in specifications		x	x	D2	SO1/2
4	Mandate to EU level standardisation organisations for further standardization.	x	x	x	D2	SO1/2
5	Mandatory deployment of V2V communication			x	D2	SO1/2
6	Non-binding guidelines on the European	x			D3	SO1/2

	Union C-ITS Security Credential Management System (EU CCMS)					
7	Binding rules on the European Union C-ITS Security Credential Management System (EU CCMS)		x	x	D3	SO1/2
8	Non-binding guidelines on the compliance assessment process for Day 1 C-ITS services	x			D4	SO1
9	Definition of compliance assessment criteria for Day 1 C-ITS services + conformity assessment procedure based on internal production control		x		D4	SO1
10	Definition of compliance assessment criteria for Day 1 C-ITS services + conformity assessment procedure based on external conformity assessment			x	D4	S01
11	Non-binding guidance for the processing of personal data in the context of C-ITS	x			D5	SO2
12	Define the purposes for lawfully processing personal data as traffic safety & efficiency, restricting other uses.		x	x	D5	SO2
13	Introducing a legal basis for the lawful processing of personal data in C-ITS			x	D5	SO2
14	Coordination & Policy Advice through stakeholder platform	x	x	x	D6/7	SO1/2/3
15	Enhanced deployment coordination + Fund EU deployment coordination after current piloting phase		x	x	D1/6/7	SO1/2/3
16	Non-binding guidelines on governance framework/bodies	x			D6	SO1/2
17	Definition of needed roles in specifications + requirement to report to the Commission on the bodies/authorities in charge.		x		D6	SO1/2
18	Definition of needed roles in EU law + Assignment of roles to legal bodies			x	D6	SO1/2
19	MoUs between key stakeholders	x	x	x	D7	SO3
20	Funding for development of services beyond the Day 1 list	x	x	x	D7	SO3
21	Strengthen funding of deployment based on specifications to enable quicker uptake, including requirement on data reporting and exchange for deployment projects		x	x	D1/7	SO1/2/3

6. WHAT ARE THE IMPACTS OF THE POLICY OPTIONS?[49]

The main impacts of the initiative are expected to be social, economic and environmental, whereby most benefits are expected to materialise in the form of a reduced number of accidents, travel time and fuel consumption resulting from the increased deployment of C-ITS services. The most significant costs will be incurred through deployment of C-ITS stations, in particular in vehicles.

49 Note: unless indicated otherwise impacts in this section are presented for the EU as a whole (EU-28). Items labelled as "PV 2020-2035" indicate monetized impacts between 2020 and 2035 in present value (2017), using the social discount rate of 4 percent.

The expected impacts of the policy options are strongly driven by the deployment of C-ITS stations and services. The deployment assumptions are thus important, in particular in PO1 and PO2 that solely rely on voluntary deployment. That is why these assumptions been developed with a close consideration of the impact mechanisms of the various policy measures, and build on significant expert input and stakeholder consultation that started in 2015. The expected deployment of C-ITS stations is described below.[50]

A model suite has been used for assessing the impacts. The first module of the modelling is a calculation of penetration rates for new vehicles, personal C-ITS devices and infrastructure. The penetration rates are then combined with impact data for different C-ITS services in the scenario module developed by the consultant RICARDO. The outputs from the scenario module, are then run through the macro-economic ASTRA/TRUST modelling framework, a strategic model based on the Systems Dynamics Modelling approach. The outputs from these two models are then processed and combined into RICARDO's cost-benefit analysis (CBA) model to produce final outputs.

The assumptions used in the quantification of each policy option are provided in Annex 4 "Analytical methods" and further detailed in the Impact Assessment Support Study.

Table 2: Cumulative deployment of C-ITS stations in 2035

Deployment of C-ITS stations	Baseline	PO 1	PO 2	PO 3
New vehicles equipped (vehicles)[51]	66.1 mn	76.9 mn	135.0 mn	186.7 mn
Personal C-ITS devices equipped	114.4 mn	134.3 mn	177.9 mn	131.2 mn
Total vehicles equipped	**180.6 mn**	**211.2 mn**	**312.9 mn**	**317.9 mn**
Infrastructure upgraded (RSU)	40000	121,000	181,000	181,000
New infrastructure deployed (RSU)	8000	21,000	142,000	189,000
Central C-ITS stations deployed	320	370	440	440
Total infrastructure equipped	**48,000**	**142,000**	**323,000**	**330,000**

50 The deployment of C-ITS services is strongly linked to the deployment of C-ITS stations, as the same station can provide multiple services, but needs to be differentiated between different types of transport, roads and C-ITS stations. Thus here only the deployment of C-ITS stations is presented.

51 The figures in this table for vehicles and personal C-ITS device are net of scrapping, i.e. C-ITS stations that have reached the end of their life-time are excluded.

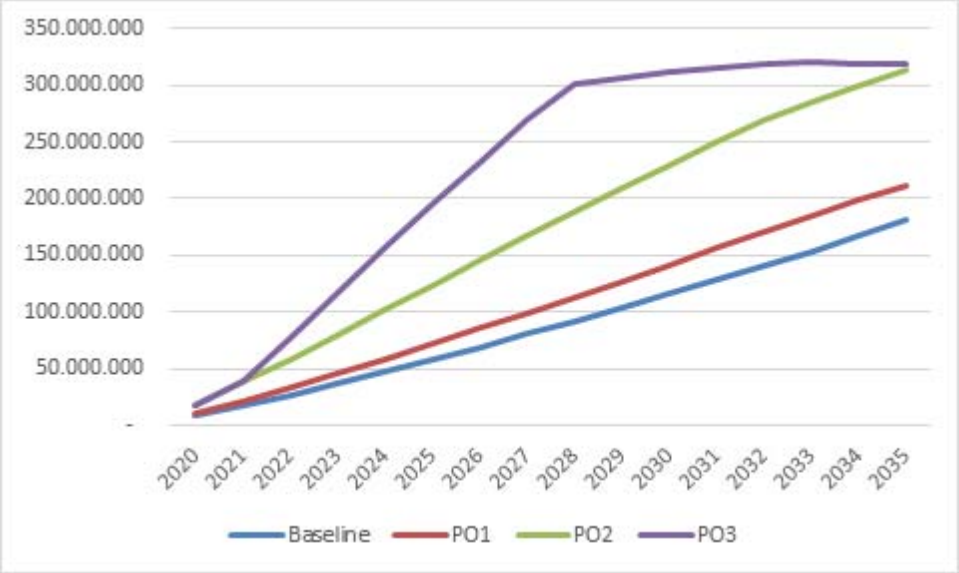


Figure 3: Number of C-ITS equipped vehicles

PO 1 is expected to have a small positive impact on deployment. In 2035, an extra 30 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 94,000 RSUs are expected to be equipped relative to the baseline, with a significant share of the overall fleet still not equipped in 2035. PO2 has significant positive impacts (an extra 132 million vehicles and 275,000 RSUs equipped) reaching 95% coverage in 2035, and PO3 very significant impacts, (an extra 137 million vehicles and 282,000 RSUs equipped), reaching 95% coverage in 2029 due to the V2V mandate.

6.1. Social impacts

Impacts on road safety

A main effect of the policy options is the reduction in the number of road accidents, as several C-ITS services (such as traffic jam ahead warning, hazardous location notification, in-vehicle speed limits, intersection safety etc.) specifically aim to improve road safety and to decrease both the number and severity of accidents.

Despite the large numbers of accidents avoided in the baseline scenario, significant further benefits are observed for all of the policy options.

Table 3: Cumulative accidents and accident costs avoided relative to the baseline for the EU – by accident type, 2030 and 2035 for PO1, PO2 and PO3

Accident Type	2020-2030		2020-2035	
	Cumulative accidents avoided relative to the baseline	Present value of accident cost avoided relative to the baseline	Annual accidents avoided relative to the baseline	Cumulative accidents avoided relative to the baseline
PO1				
Fatalities	1,300	€2 bn	3,700	€4 bn
Serious injuries	15,000	€3 bn	46,000	€8 bn
Minor injuries	69,000	€1 bn	199,000	€3 bn
Total	**85,000**	**€6 bn**	**249,000**	**€15 bn**
PO2				

Fatalities	5,500	€8 bn	14,100	€17 bn
Serious injuries	54,000	€11 bn	152,000	€27 bn
Minor injuries	260,000	€4 bn	700,000	€10 bn
Total	**320,000**	**€23 bn**	**866,000**	**€53 bn**
PO3				
Fatalities	9,500	€13 bn	20,900	€26 bn
Serious injuries	88,000	€18 bn	209,000	€38 bn
Minor injuries	435,000	€7 bn	992,000	€14 bn
Total	**533,000**	**€38 bn**	**1,222,000**	**€77 bn**

Note: Accidents have been rounded to the nearest 1,000, save for fatalities, which is rounded to the nearest hundred.

PO1 would result in a reduction of 3,2% in the number of accidents compared to the baseline in 2035, or an annual reduction of 4,2 billion euros in social costs (or a reduction of 1.0% of the PV of accident costs, or 15 billion euros, between 2020 and 2035). At Member State level the impacts on accidents range between a 2,2% reduction in Poland and a 4,8% reduction in Luxembourg. While there are numerous factors that underlie this difference between Member States, which cannot be separated out in the modelling, an important factor seems to be speed of fleet renewal, with MS such as Belgium and Luxembourg with high fleet renewal showing larger benefits.

PO2 would result in a reduction of 10,4% in the number of accidents compared to the baseline in 2035, or an annual reduction of 13,6 billion euros in social costs (or a reduction of 3,5% of the PV of accident costs, or 53 billion euros, between 2020 and 2035). At Member State level the impacts on accidents range between a 7,8% reduction in Poland and a 12,7% reduction in Luxembourg.

PO3 would result in a reduction of 11,9% in the number of accidents compared to the baseline in 2035, or an annual reduction of 15,6 billion euros in social costs (or a reduction of 5,0% of the PV of accident costs, or 77 billion euros, between 2020 and 2035). At Member State level the impacts on accidents range between a 9,5% reduction in Poland and a 14,3% reduction in Luxembourg.

While all three policy options deliver a reduction in social costs by 2035 (expressed as present value), the impacts of PO2 and PO3 are 3 to 4 times larger than the impact of PO1.

Impacts on vulnerable road users

A considerable proportion of road accidents currently affect Vulnerable Road Users (VRUs); in 2015, 29 percent of all road deaths were pedestrians and cyclists.[52]

Whilst a number of the Day 1 services being deployed in the policy options are aimed at improving safety generally, none of them are specifically aimed at the safety of pedestrians and cyclists. Several stakeholders already foresee the development of specific Day 1.5 services to protect VRUs building on the same C-ITS architecture. However, these services are not yet mature enough to be considered in service specifications or the assessment of impacts. The funding for the development of services beyond Day 1 in all policy options and additionally the coordination mechanisms included in PO2 and PO3 could support this.

Stakeholders advocate that C-ITS that enables interaction between all vehicles – including bicycles – is expected to have potential significant benefits for road safety, including for VRUs. However, it was considered that several issues need to be actively addressed, for instance

[52] ETSC, 2016. Briefing: Prioritising the safety potential of automated driving, European Transport Safety Council. [Online] Available at: http://etsc.eu/wp-content/uploads/2016_automated_driving_briefing_final.pdf

avoiding that C-ITS are a distraction to the drivers and reducing the risk to VRUs during the introduction and transitional stages towards automated driving.

In this light, more consideration of other modes (including VRUs) in the development of C-ITS could be of wider benefit and better help cities to deliver modal shift. The funding for the development of services beyond Day 1 in all policy options and additionally the coordination mechanisms included in PO2 and PO3 could support this. Concluding, all policy options have a limited impact on the safety of VRUs based on the deployment of Day 1 C-ITS services, while PO2 and PO3 can have a small impact through the coordinated development of additional C-ITS services with specific benefits for VRUs.

6.2. Economic impacts

Investment and operating costs

In the deployment of C-ITS technologies, an important cost factor consists of C-ITS equipment for new vehicles, personal C-ITS devices, roadside infrastructure upgrades, new roadside infrastructure, and central sub-systems. This also includes operating costs such as software development, maintenance, data communications and secure communications.

Table 4: Present value of equipment costs relative to the baseline for EU28 – 2030 / 2035

Scenario	PV 2020-2030	Additional PV costs relative to the baseline in 2030	PV 2020-2035	Additional PV costs relative to the baseline in 2035
Baseline	€9.6 bn	-	€17.7 bn	-
PO1	€12.5 bn	€2.8 bn	€22.6 bn	€4.9 bn
PO2	€20.9 bn	€11.3 bn	€36.8 bn	€19.1 bn
PO3	€30.7 bn	€21.1 bn	€50.0 bn	€32.3 bn

To illustrate the relative importance of different cost items, Figure 4 shows a breakdown of the annual equipment costs each year (in present value terms) relative to the baseline. In all three policy options, in-vehicle C-ITS equipment (new vehicles + personal C-ITS devices) represent the large majority of costs, compared to infrastructure C-ITS equipment. Annual total equipment costs generally increase year on year for PO1 and PO2, but in PO3 they peak in 2028, which is the point at which 100 percent of new vehicles in the fleet have been equipped.[53]

53 A detailed description on the estimation of cost elements and their sources can be found in Annex B.2.4 of the support study.

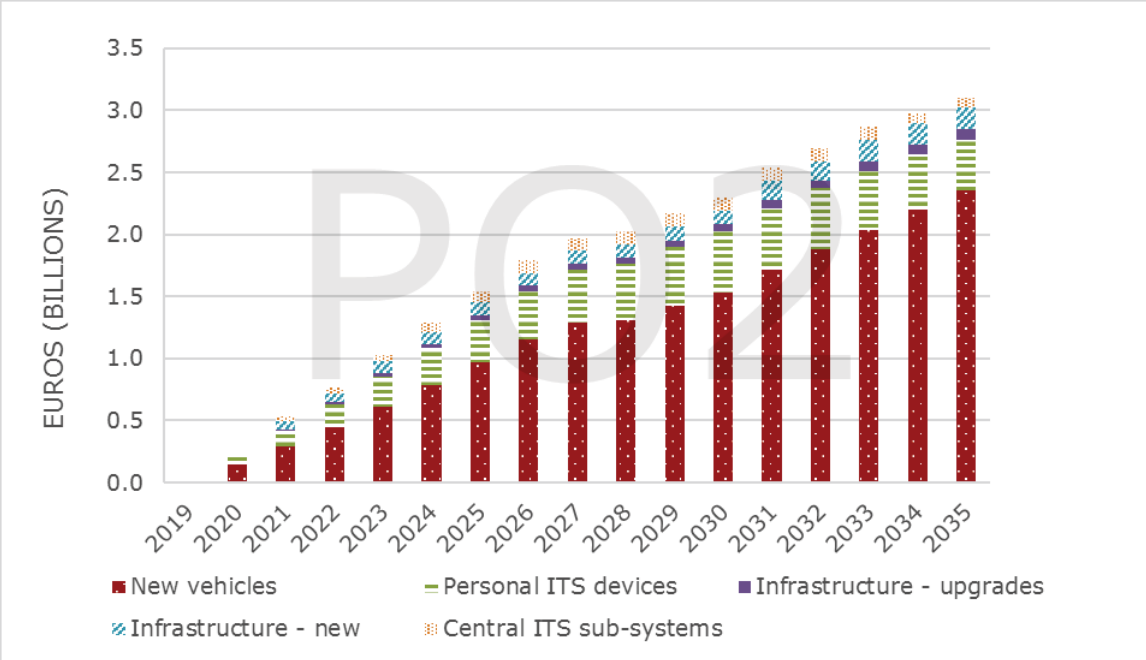


Figure 4: Total annual equipment costs: Composition of costs relative to baseline for EU 28

Looking at the distribution of these costs, if we assume that infrastructure costs are borne by the public sector and vehicle & personal C-ITS device costs by the private sector (manufacturers could increase prices to shift (part of) these costs to consumers), most costs are assigned to the private sector (77%, 87% and 91% of total cost in 2035 in PO1, PO2 and PO3 respectively).

Compliance costs

Under PO1, compliance with the guidelines is voluntary and as such, there are no significant compliance costs. PO2 and PO3 put in place a number of legal requirements that have associated compliance costs:

- **Security (PO 2&3):** the costs associated with the set-up and operation of the CCMS. In the early deployment phase the costs of the common elements are financed through the Connecting Europe Facility, but it is still to be determined how these costs will be covered in the future. The costs of secure communication have been estimated to be only a small part of the overall cost of a C-ITS station[54] and are included in the equipment cost estimates.
- **Interoperability (PO 2&3):** There will be some costs associated with making existing C-ITS stations compatible with the specifications. However, this only affects a relatively limited number of stations, which will not be interoperable otherwise. Likewise, stakeholders intending to integrate new services or technologies (such as LTE-V2X) into the C-ITS network could incur costs to ensure compatibility with the specifications.
- **Governance bodies (PO3):** In PO3 governance bodies would be set up, which would require funding. If these are set-up through EU legislation, the costs would also likely be covered at the EU level, and the costs for Member States and C-ITS stakeholders would be limited to participation.

54 Euro 2,56 for an in-vehicle C-ITS station per year, compared to Euro 290 total upfront cost.

- **V2V mandate (PO3):** In case of a V2V mandate, the costs associated with in-vehicle C-ITS devices, a very significant part of overall equipment costs (EUR 57 billion out of EUR 78 billion), should be considered compliance costs.

Administrative costs

In PO2 and PO3[55] there are administrative costs associated with the compliance assessment of C-ITS stations, which will fall predominantly on the manufacturer of the C-ITS station, but also on public authorities in the form enforcement costs. However, these costs are considered to be small compared to the overall costs of C-ITS stations, and in the absence of a mandatory compliance assessment process (i.e. in the baseline and PO1), stakeholders would still require reassurance on the functioning of C-ITS stations of other actors.

Additionally, measure 17 (PO2) and measure 21 (PO 2&3) include a reporting obligation on C-ITS bodies and authorities, and on EU funding projects. However, the associated administrative costs are considered insignificant compared to the overall costs of the policy option.

Urban travel time

Some Day 1 C-ITS services reduce urban travel time, namely Hazardous location notification (HLN) and Traffic signal priority request by designated vehicles (TSP). These represent relatively modest reductions in overall annual urban travel time (0,12%, 0,70% and 1,61% in 2035 compared to the baseline for PO1, PO2 and PO3 respectively), but given the high number of hours lost in traffic (and the fact that this is increasing under the baseline scenario), the monetary value of these savings is significant.[56] Furthermore, the introduction of Day 1.5 services is expected to make a significant additional contribution to the reduction of urban travel time.[57]

Table 5: Present value total urban travel time savings relative to the baseline for the EU28 – 2030 / 2035

Scenario	PV 2020-2030	PV 2020-2035
PO1	€0.5 bn	€2.0 bn
PO2	€2.5 bn	€10.8 bn
PO3	€7.7 bn	€28.2 bn

Fuel consumption

C-ITS services aimed at smoothing out uneven traffic flow and at reducing urban travel time (e.g. hazardous location notification and traffic signal priority) will additionally lead to a reduction in fuel consumption. Again, these represent relatively modest reductions in overall fuel consumption (PV 2020-2035 fuel consumption costs[58] reduced by 0,1%, 0,4% and 0,7% in PO1,

55 Also in PO1, C-ITS manufacturers will likely face costs associated to compliance assessment, as other C-ITS operators have to be reassured that systems can work together.

56 The monetary value was calculated based on the cost of time values from the Handbook of External Costs, see section 5.2.2.3 of the support study for more details.

57 See section 6.4 on sensitivity analysis.

58 The fuel price is calculated as a weighted average of prices of gasoline, diesel, CNG, LPG and electricity, based on energy consumption of road transport modes, excluding excise duties and VAT.

PO2, PO3 respectively compared to the baseline), but the monetary value of these savings is significant.

Improvements in transport efficiency, leading to lower travel times and fuel consumption, can induce increased transport demand, negating some of these benefits (the so-called rebound effect). The model suite used for this Impact Assessment includes feedback loops that reflect this.

Table 6: Present value fuel costs and savings relative to the baseline for EU28 – 2030 / 2035

Scenario	PV 2020-2030	PV 2020-2035
PO1	€1.1 bn	€2.5 bn
PO2	€4.9 bn	€11.2 bn
PO3	€9.2 bn	€18.2 bn

As a result of this reduced fuel consumption, fuel duty revenues are also expected to reduce.

Table 7: Annual fuel duty revenue changes by policy option relative to the baseline for the EU28 – 2030 / 2035

	PO1		PO2		PO3	
Grouping	2030	2035	2030	2035	2030	2035
EU 28	-0.15%	-0.26%	-0.66%	-1.13%	-1.19%	-1.41%

Other economic impacts

Another impact is **new job creation** related to the manufacturing, installation, maintenance and operation of new C-ITS technologies. The total direct and indirect jobs created are positive but limited: 17.850, 68.810 and 85.370 in 2035 under PO1, PO2 and PO3 respectively.[59] Stakeholder responses in the Public Consultation (PC) were positive on the potential employment impacts of C-ITS. When asked about the impact of the likely new services that will come into the market due to C-ITS and create new jobs, nearly all respondents agreed with the statement that new jobs would be created as a result.

Regarding **research & innovation**, as C-ITS deployment means an increase in firms sharing electronic data and using ICT, it is expected that companies participating in the market would benefit from increased product innovation. In responses to the Commission's Public Consultation, most stakeholders (106 out of 135) agreed with the Commission's suggestion that the deployment of C-ITS will have a positive impact on research and innovation.[60]

Many of the case studies show a lot of research and innovation in C-ITS and suggest that the new information made available by C-ITS could lead to innovation as companies identify new ways of using these data. A clearer framework for C-ITS deployment and future funding in Policy options 2 and 3 may further improve R&I impacts compared to the baseline.

An important consideration here is also the link between C-ITS, new technologies and other ITS applications. The creation of a common, interoperable C-ITS network is crucial to create positive network effects and a sustainable eco-system supporting innovation. At the same time, setting

59 These results should be considered with care as they may be offset by job losses in other areas which are not reflected in the analysis. See Section 5.2.5 of the Support Study for more details.

60 See Figure 2-28 in the Public Consultation report.

specifications (in particular if they are legally binding), requires new technologies to adapt to these specifications, creating potential barriers for their introduction. That is why on open system, based on review of the specifications to integrate new, mature technologies, and ensure synergies with other ITS applications should be at the basis of all policy options.

SMEs are likely to play a significant role in C-ITS, as SMEs are well represented in both the supply of C-ITS technologies, and as data and transport companies; SMEs are also active participants in the current C-ITS deployment projects. In the Public Consultation a number of stakeholders considered that standardisation and 'legally-enforced transparency' were important to enable SMEs to access the C-ITS market, although it was considered that binding rules should not result significant compliance and administrative costs or reduce the potential for innovation, as this might limit the participation of SMEs.

The enhanced deployment of C-ITS may also give SMEs greater roles for providing innovative products and services to the market. In this sense, PO 3 is likely to have the greatest impact due to higher deployment, but PO 2 may also give companies in the market much needed regulatory certainty to enable them to make efficient investments in new products and services.

The analysis found insignificant effects on overall GDP and the split between transport modes.

6.3. Environmental impacts

CO_2 emissions

As a result of lower fuel consumption, CO_2 emissions are also expected to reduce. In 2035, the annual CO_2 reductions relative to the baseline for PO1, PO2 and PO3 represent 0.3%, 1.1% and 1.4% of total baseline emissions, respectively.

The cumulative monetary savings relative to the baseline between 2020-2035 resulting from reduced CO_2 emissions are greatest in PO3, with present value savings of €5.3 billion by 2035. This is in comparison to €0.7 billion and €3.2 billion by 2035, for PO1 and PO2 respectively.

Pollutant emissions

The analysis also considers the emission of air pollutants, namely NOx, VOC and PM. In 2035, the annual emissions savings relative to the baseline for PO1, PO2 and PO3 represent 0.1%, 0.3% and 0.3% of total baseline emissions, respectively.

The cumulative savings relative to the baseline are greatest in PO3, where they amount to €0.16 billion between 2020-2030 and €0.29 billion between 2020-2035 (in present value terms). In comparison, the cumulative savings between 2020-2035 of PO1 and PO2 are €0.07 billion and €0.20 billion respectively. These are minor compared with the cumulative savings presented for CO_2 emissions and fuel consumption.

6.4. Fundamental rights

Personal data

As discussed in Section 2.3.5 and Annex 6, data sent by C-ITS services from vehicles often qualifies as personal data, and this is particularly relevant in the case of cooperative awareness messages (CAMs), which are an essential element for the functioning of C-ITS. With regard to personal data, any successful C-ITS deployment must be compliant with the applicable legal framework for data protection (including the General Data Protection Regulation (GDPR -

Regulation 2016/679) and, where applicable, the ePrivacy Directive (Directive 2002/58)[61] to increase trust among users.

Thus, these instruments determine the main requirements for data protection, including in particular the ground for the lawfulness of processing and the need for the data controller to carry out a data protection impact assessment, while the measures under this initiative rather facilitate the compliance with these requirements. Thus all policy options should provide the same level of protection of personal data in C-ITS.

That being said, the policy options differ in how far they support data controllers in complying to data protection rules. Policy option 1 only provides non-binding guidance with limited effect on helping compliance and increasing public acceptance. Policy option 2 would further help by establishing some clear rules and limitations. Most support would come from policy option 3, where the V2V mandate could provide a legal basis for the processing of personal data.

6.5. Distributional impacts & Sensitivity Analysis

Some limitations of the impact assessment are due to uncertainties around the input assumptions for the modelling. In particular, the fact that the impact assessment examines the future impacts of technologies not yet in place beyond trial projects, has some necessary limitations in terms of the information available on potential deployment (assumptions build on the intentions of MS and some industry players to deploy, which is then cautiously extrapolated to the whole EU) and associated impacts (which build on the result of research and pilot projects).[62]

The model suite used for this analysis was primarily designed to calculate EU level impacts. While impacts per MS can be extracted from the modelling output (see Annex 4 "Analytical methods"), these are the result of input assumptions mostly at the EU level, and thus have to be considered with significant caution.

Looking at the impacts at MS level, all but 3 MS in PO1 and all MS in PO2 and PO3 show positive net benefits. MS with a lower average vehicle age seem to have higher positive impacts, which makes sense as this likely implies a quicker penetration of C-ITS in the vehicle fleet.[63] The MS with the lowest (but still positive) absolute benefits and benefits/costs ratio are Malta and Cyprus, which might be explained by the fact that costs for central & infrastructure stations are more significant in the smaller MS.

To assess the impact of uncertainties around these input parameters, we have carried out a number of sensitivity analyses to check if the analysis was robust against changes in assumptions.[64]

Table 8: Cumulative net present value (NPV) for each policy option relative to the baseline, with and without sensitivities applied

	PO1	PO2	PO3
	2020-2035	2020-2035	2020-2035

61 A proposal for the revision of the ePrivacy in currently being negotiated.

62 The limitations of the analysis are described in more detail in chapter 7 of the support study.

63 No such relationship was found for MS with higher fatalities/capita or front-runners in C-ITS deployment, where this might have been expected.

64 More details can be found in Annex 4, section 2 and chapter 7 of the support study

NPV benefits	€15.4 bn	€59.8 bn	€96.5 bn
NPV benefits after 50% equipment cost increase	€13.5 bn	€51.5 bn	€81.8 bn
NPV benefits after 10% impact reduction	€12.6 bn	€48.9 bn	€80.7 bn
NPV benefits after 10% deployment reduction	€11.2 bn	€43.4 bn	€85.5 bn

1. 50% cost increase of C-ITS equipment, with stable benefits

While this is a significant cost increase, each policy option still shows a positive NPV even with increased cost assumptions, because total equipment costs are small compared to total societal benefits.

2. 10% reduction of C-ITS service impacts[65]

As expected, a reduction in the assumed impact of each individual C-ITS service, to account for a possible overestimation of impacts based on research and pilot projects, results in a similar negative change across all impact categories and policy options The reduction of impacts is slightly more than proportional (12 to 14 %) to the 10% decrease.

3. 10% decrease of deployment rates[66]

As expected, a reduction of the deployment rates, to account for the possibility that MS and industry do not invest in C-ITS as quick as assumed, results in a negative change across all impact categories and policy options. For PO1 and PO2, the reduction of impacts is more than proportional (12 to 25%) to the 10% decrease in deployment. For PO3, the reduction is less pronounced (-9%) due to the V2V mandate in place.

Sensitivity analyses 1,2 and 3 show that the net benefits are quite robust under negative assumptions and they do not change the relative order of the policy options in terms of net benefits (see Table 8).

4. Extension of scope to Day 1.5 services (PO3)[67]

This sensitivity considers the impact of adding additional Day 1.5 services[68] to the C-ITS eco-system. It is expected that this will significantly increase overall benefits, while having only a

65 Within the modelling framework, sensitivity analyses 2 and 3 require significant changes to the modelling scenarios. PO2 and PO3 sensitivities have been fully modelled in the ASTRA/TRUST environment and the CBA model. As PO1 is discarded in section 8, its sensitivity impacts have been estimated from the modelled changes between PO2 and the PO2 deployment sensitivity.

66 For PO1 and PO2 both the in-vehicle and infrastructure deployment has been decreased by 10%. For PO3 however, only the infrastructure deployment has been decreased as the vehicle deployment is fixed through the V2V mandate.

67 As this analysis requires significant changes to the modelling framework, it has only been carried out for the most ambitious policy option, as it considers future extension of the C-ITS eco-system.

68 Services considered to be mature, but not quite ready for a large-scale deployment due to a lack of full specifications or standards, and which are thus not included in the main policy options.

limited impact on costs, as it is expected that existing C-ITS stations can be used to deliver these services with only minor software adjustments.[69]

The addition of Day 1.5 services is expected to result in significantly higher total benefits of 303 billion euros instead of 129 billion euros (PV 2020-2035) in PO3, compared to the baseline. This increase of impacts results in particular from Day 1.5 services which help drivers save time, by providing information on parking availability or enhanced traffic routing. As a result of these time saving services, significant fuel consumption and CO2 emissions savings are achieved. Additionally, services specifically aimed at the protection of vulnerable road users will help further reduce accident costs.

7. HOW DO THE OPTIONS COMPARE?

7.1.1. Effectiveness

The effectiveness of the intervention is measured by the extent to which the specific and general objectives of the policy intervention are met, and the resulting societal, economic and environmental benefits of C-ITS services. Table 9 lists the specific objectives along with their assessment criteria, which are linked to the problem drivers identified in the problem definition.[70]

Table 9: Specific objectives and their assessment criteria

Specific Objectives	Assessment criteria
Ensure interoperability and continuity of C-ITS services across the EU	• Establishment of common definition / priority of C-ITS services • Increased certainty with regards to interoperability requirements for C-ITS stations
Reduce barriers and uncertainties to enable large-scale deployment of C-ITS	• Increased trust with regards to cyber security of C-ITS communications • Better public acceptance due to the consistent application of rules on privacy and protection of personal data • Increased certainty with regards compliance assessment requirements for C-ITS services
Provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models	• Improved coordination between C-ITS bodies & stakeholders • Increased certainty about C-ITS business models

Table 10: Comparison of options on achievement of objectives

Assessment Criterion	PO1	PO2	PO3
General Objective: Increase deployment and uptake			

69 Given their limited size and unpredictability, these increased costs have not been included in the sensitivity for reasons of simplification.

70 While several problem drivers are linked to multiple main problems, in this section each assessment criterion is only mentioned under one specific objective to improve the presentation.

Deployment/uptake levels	In 2035, an extra 30 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 94,000 RSUs equipped relative to the baseline, with a significant part of the fleet not yet equipped.	In 2035, an extra 132 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 275,000 RSUs equipped relative to the baseline.	In 2035, an extra 137 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 282,000 RSUs equipped relative to the baseline. As a result of the V2V mandate, this deployment is earlier (95% coverage in 2029) and more certain than in PO2.
Specific objective 1: Ensure interoperability and continuity of C-ITS services across the EU			
Establishment of common definition / priority of C-ITS services	Non-binding guidelines will be an important step in providing a common definition of C-ITS services and emphasises the focus on Day 1 services. While the availability of such guidelines will have a positive impact, the application of common C-ITS service definitions will be limited to where they are voluntarily applied.	The definition of Day 1 services list in specifications and the requirement for C-ITS stations to be compatible with all Day 1 services will ensure that everywhere where C-ITS services are applied common definitions are followed.	Same as PO2
Increased certainty with regard to interoperability requirements for C-ITS stations	Given its non-binding nature, reference to existing standards on interoperability and EU-wide service profiles in non-binding guidelines will have a limited, though positive impact on interoperability.	Mandatory compliance with and EU wide service and system profiles will have a strong positive impact on interoperability. Ensuring future updates of the specifications through a review clause will ensure that technological developments can be integrated.	Same as PO2. In addition the V2V mandate will ensure deployment in line with the specifications.
Specific objective 2: Reduce barriers and uncertainties to enable large-scale deployment of C-ITS			

Increased trust with regards to cyber security of C-ITS communications	The non-binding nature of security guidelines gives a limited but positive effect.	By mandating C-ITS station operators to fulfil the security requirements, a single trust domain for all C-ITS stations is created, significantly increasing security and interoperability of C-ITS communications.	The assignment of tasks to legal bodies will guarantee the necessary coordination and management of security issues, thus ensuring that concerns around security are reduced to a minimum.
Better public acceptance due to the consistent application of rules on privacy and protection of personal data	Provision of non-binding guidance for processing personal date in the context of C-ITS will remove some of the uncertainties, though due to the non-binding nature this measure will result in only small impacts on public acceptance.	Providing specifications on the processing will further remove barriers and increase public acceptance. Clearly limiting the purposes for lawfully processing personal data to traffic safety and efficiency will alleviate some of the concerns related to personal data use.	Lawfully processing data based on a legal obligation or public interest which is specified in EU law will further remove barriers and increase public acceptance.
Increased certainty with regards compliance assessment requirements for C-ITS services	Non-binding guidelines on the compliance assessment process and to assign roles and responsibilities, will slightly increase certainty, however, the impacts will be limited	Providing compliance assessment criteria and procedures for C-ITS stations based on internal production control will provide increased certainty about conformity	Providing compliance assessment criteria and procedures for C-ITS stations based on external conformity assessment will provide increased certainty around conformity, as well on its impartiality and independence
Specific objective 3: Provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models			
Improved coordination between C-ITS bodies & stakeholders	Guidelines on governance structures for security and compliance assessment will help with coordination within MS. Since these bodies do not have to be set up or reported to the Commission the EU level coordination will be limited. The set-up of a stakeholder platform will improve the	The requirement to report bodies set up for security and compliance assessment to the Commission will further improve coordination across Europe, under the premise that these bodies are actually set up. Enhanced deployment coordination will further improve coordination at EU level.	The assignment of roles to legal bodies would ensure that all tasks & roles are carried out. This will have significant additional impacts on overall coordination between relevant bodies compared to PO2.

	exchange of knowledge and best practices		
Increased certainty about C-ITS business models	Provision of non-binding guidelines will only remove a limited number of uncertainties for C-ITS business models. Stakeholder platform will help in further elaborating a common vision/approach for C-ITS deployment.	Provision of common binding specifications will significantly increase the change of interoperable implementations and network effects. Deployment coordination & funding will contribute to sustainability of early deployment.	The V2V mandate, combined with deployment coordination, will strongly speed up deployment and network effects, providing increased certainty for investments.
Societal, economic and environmental benefits			
Fuel consumption	Limited impact. PV 2020-2035 fuel consumption costs reduced, 2,5 billion euros or -0.1% compared to the baseline.	Positive impact, PV 2020-2035 fuel consumption costs reduced, 11 billion euros or -0.4% compared to the baseline.	Positive impact, PV 2020-2035 fuel consumption costs reduced, 18 billion euros or -0.7% compared to the baseline.
CO_2 emissions	Limited impact, PV 2020-2035 CO_2 emission costs avoided, 0,7 billion euros or -0.1% compared to the baseline.	Limited impact, PV 2020-2035 CO_2 emission costs avoided, 3,2 billion euros or -0.1% compared to the baseline.	Positive impact, PV 2020-2035 CO_2 emission costs avoided, 5,3 billion euros or -0.6% compared to the baseline.
Pollutant emissions – PM, NOx, VOC	Limited impact. PV 2020-2035 other pollutant emission costs avoided, 0,1 billion euros or -0.0% compared to the baseline.	Limited impact. PV 2020-2035 other pollutant emission costs avoided, 0,2 billion euros or -0.1% compared to the baseline.	Limited impact. PV 2020-2035 other pollutant emission costs avoided, 0,3 billion euros or -0.1% compared to the baseline.
Accidents	Positive impact. PV 2020-2035 accident costs avoided, 15 billion euros or -1.0% compared to the baseline	Positive impact. PV 2020-2035 accident costs avoided, 53 billion euros or -3.5% compared to the baseline.	Strongly positive impact. PV 2020-2035 accident costs avoided, 77 billion euros or -5.0% compared to the baseline.

Urban travel time	Limited impact. Increased travel time savings relative to baseline between 2020 and 2035 (+ 0.03%) or 2,0 billion euros.	Positive impact. Increased travel time savings relative to baseline between 2020 and 2035 (+0.16%) or 11 billion euros.	Strongly positive impact. Increased travel time savings relative to baseline between 2020 and 2035 (+0.42%) or 18 billion euros.

As the impacts of C-ITS services increase with deployment, the effectiveness of the policy options in terms of delivering benefits (such as reduced accidents, fuel consumption, CO_2 emissions, pollutant emissions and travel time) increases from PO1 to PO3. PO3 is the most effective, achieving more than 6 times the benefits of PO1, and 64% more benefits than PO2. In addition, PO3 would provide the most supportive framework for C-ITS, by introducing a stable governance framework and a legal basis for the lawful processing of personal C-ITS data.

7.1.2. Efficiency

The efficiency is assessed by comparing the costs and benefits that have been monetized. Table 10 shows the main monetized costs and benefits associated with the policy options. Section 6.2 discusses additional administrative and compliance costs, but as these are considered very minor compared to the cost items presented here and thus do not alter the assessment (with the exception of the compliance costs for the V2V mandate in PO3), they are not repeated here.

PO3 shows the highest net benefits, followed by PO2 and then PO1. The benefit-costs ratio (approximately 4) is very similar between all three policy options and should not be used to distinguish between the policy options, considering the uncertainties in these estimates and the limitations of the modelling framework.

It needs to be considered that unlike PO1 and PO2 where uptake is voluntary, PO3 includes a V2V mandate, and a large share of the costs for in-vehicle equipment (57 billion euros) should thus be considered as compliance costs in the PO3 (notwithstanding that deploying stakeholders would also incur this costs in a voluntary deployment scenario). In this light, PO1 and PO2 could be considered to be more efficient than PO3 in achieving the objectives, however it should also be acknowledged that the impacts in PO1 and PO2 are less certain, and that PO3 foresees in a stepwise approach in which the efficiency of a mandate can be reassessed.

Table 11: Summary of monetized costs and benefits (PV 2020-2035) compared to the baseline for the different policy options

	PO1	PO2	PO3
In-Vehicle Equipment costs (PV 2020-2035)	€2.9 bn	€12.8 bn	€23.6 bn
Personal C-ITS Devices costs (PV 2020-2035)	€0.9 bn	€3.8 bn	€5.9 bn
Upgraded RSU costs (PV 2020-2035)	€0.3 bn	€0.5 bn	€0.4 bn

New RSU costs (PV 2020-2035)	€0.1 bn	€1.2 bn	€1.5 bn
Central sub-systems costs (PV 2020-2035)	€0.7 bn	€0.9 bn	€0.9 bn
Total equipment costs (PV 2020-2035)	**€4.9 bn**	**€19.1 bn**	**€32.3 bn**
Accident reduction benefits	€15.0 bn	€53.4 bn	€76.9 bn
Time saved benefits	€2.0 bn	€10.8 bn	€28.2 bn
CO2 emission benefits	€0.7 bn	€3.2 bn	€5.3 bn
Other emissions benefits	€0.1 bn	€0.2 bn	€0.3 bn
Fuel saving benefits	€2.5 bn	€11.2 bn	€18.2 bn
Total Benefits (PV 2020-2035)	**€20.3 bn**	**€78.9 bn**	**€128.9 bn**
% modelled costs incurred by private sector (PV 2020-2035)	76.9%	86.8%	91.2%
% modelled costs incurred by public sector (PV 2020-2035)	23.1%	13.2%	8.8%
Total net benefits (PV 2020-2035)	**€15.4 bn**	**€59.8 bn**	**€96.5 bn**

7.1.3. Coherence

Coherence describes how each policy option is in line with relevant legislation as well as with EU transport policies in a broader perspective. In terms of coherence with the goals of the ITS Directive and broader transport policies, PO2 and PO3 score significantly better than PO1 by ensuring the interoperability of C-ITS services, and thus increasing the certainty of deployment and achievement of benefits relevant for overall transport policy goals. PO3 in addition provides extra support to the continuity of services through the V2V mandate.

All policy options are coherent with legislation related to data exchange (i.e. the GDPR and the e-privacy and EECC proposals), as they do not affect the application of this legislation, but provide more clarity on how C-ITS would function in relation to this legislation. PO1 would provide the lowest level of additional clarity due to its non-binding nature, whereas PO3 would provide the most certainty by providing a legal basis for the lawful processing of personal data.

The coherence assessment is summarized in the table below. Overall, all policy options are considered coherent, but PO2 and PO3 are considered more coherent than PO1 because of the added certainty and the alignment with transport policy goals.

Table 12: Comparison of options on coherence

	PO1	PO2	PO3
ITS Directive	0	+	++
Transport policies (e.g. Transport White Paper, Low Emission Mobility Strategy	+	++	++
GDPR	0	+	+
E-privacy & EECC proposals	+	+	+
Overall coherence	+	++	++

7.1.4. Proportionality

PO1 relies on non-binding guidance and thus allows Member States and individual deployment projects to decide whether or not to comply with the provided guidelines. In this sense, PO1 is proportional to achieving the intended objective.

PO2 is based on a Delegated Act under the ITS Directive. Compliance would only be mandatory when deploying C-ITS services. While binding EU specifications do require existing C-ITS stations and new technological solutions to adapt to the requirements, these requirements are essential to ensure EU-wide interoperability of C-ITS services, and the foreseen review allows for flexibility in the development of technological solutions. While it is a more stringent measure than PO1, the expected benefits, both direct and indirect, are also proportionally higher.

In discussions with MS experts, some MS argued for a technological-neutral framework where the choice of technology is left to the market, but a strong majority agreed with the need for clear EU specifications to ensure interoperability, starting with mature implementations available now, and including a clear and transparent path for the inclusion of future solutions and technologies. Thus, PO2 is considered proportional.

PO3 would, in a second step following specifications, impose an obligation on vehicle manufacturers to equip all their new vehicle types with C-ITS stations. While some OEMs have already made announcements to equip (parts of) their fleet, this policy option would make that mandatory. Since significant direct and indirect impacts are already expected following the adoption of specifications without resorting to a V2V mandate (See results of PO2), the proportionality and necessity of a mandate can be further assessed, in line with the stepwise approach foreseen in the ITS Directive. This also ensures that the scope of the system is clearly defined through specifications, before the implications of deployment are considered in more detail. It is important to note, that this second step is not part of the current initiative, and would require a separate proposal accompanied by an additional impact assessment.

8. PREFERRED OPTION

As the different policy options score differently on the various criteria, a trade-off should be made in selecting the preferred option.

- Effectiveness: **PO3** is the most effective regarding deployment and benefits, followed by PO2 and PO1. In addition, PO3 also provides the most certainty about the level of deployment through the V2V mandate, whereas PO1 and PO2 rely on voluntary deployment and might lag behind expectations.
- Efficiency: All POs show a similar benefit-cost ratio. PO3 achieves the highest and most certain net benefits, but at the same time the V2V mandate introduces significant compliance costs on car manufacturers, whereas PO1 and PO2 rely on voluntary deployment. Thus, **PO1** and **PO2** are considered the most efficient in achieving the objectives at this stage.
- Coherence: Overall, all POs are considered coherent with the ITS Directive, legislation on data exchange and broader transport policy objectives, but **PO2** and **PO3** are considered more coherent than PO1 because of the added certainty for the deployment and achievement of benefits relevant for the transport system.
- Proportionality: Both **PO1** and **PO2** are proportional – allowing Member States and industry to determine the level of deployment they prefer. PO3 provides higher deployment and added certainty, but also imposes a direct obligation on vehicle manufacturers, the proportionality and necessity of which can be further assessed in a step-wise approach.

Based on this assessment, PO2 is clearly preferred over PO1**,** as it achieves significantly larger benefits and is more coherent than PO1. PO3 is even more effective and coherent that PO2, providing more certainty on deployment and more effectively addressing the problem drivers of data protection and lack of coordination, but at the same time the V2V mandate would introduce significant compliance costs, and the efficiency and proportionality of the mandate should be further assessed. **The preferred approach is thus PO3, following a step-wise approach as foreseen in the ITS Directive,** where after the adoption of specifications a proposal on deployment can be made to the European Parliament and the Council, which should take the voluntary deployment of C-ITS following the adoption of specifications into account. It is important to note, that this second step is not part of the current initiative, and would require a separate proposal accompanied by an additional impact assessment.

9. HOW WILL ACTUAL IMPACTS BE MONITORED AND EVALUATED?

Monitoring and evaluation should build on a simple approach that is transparent and easily accessible. It is not the intention to create a very complex and complicated system of key performance indicators.

More specifically, the Commission services will monitor the implementation and effectiveness of this initiative through a set of core indicators that will measure the progress towards achieving the specific objectives, based on the measures that are part of the preferred option. Some of the indicators are of a qualitative nature and show if the desired deliverables are being achieved and implemented, while others are based on data to be collected that will need to be analysed further. In addition, the social, economic and environmental impacts will be monitored based on available statistics (e.g. the CARE database for accidents, and Eurostat statistics for fuel use and CO_2 emissions) and new/updated studies (e.g. for air pollutants and congestion).

Considering that C-ITS is a fast-moving sector, it is foreseen that the Commission services will carry out an evaluation after 3 years to verify whether the objectives of the initiative have been reached. This is intended to determine whether the measures in place have resulted in an improvement of the situation. This evaluation shall be carried out based on the core progress indicators below, in line with Commission requirements on evaluation. The evaluation will also include data collection on investment, operating and compliance costs resulting from C-ITS deployment, and a qualitative and quantitative assessment of any issues that have arisen regarding data collection and management.

Table 13: Monitoring and reporting

Specific objective	Progress indicators	Source of data
Ensure interoperability and continuity of C-ITS services across the EU	Number of C-ITS stations deployed % of road network type covered by C-ITS services Standardisation and profiling of new C-ITS services and communication methods Revisions of the specifications to take into account technological progress	C-ITS stations registered in the CCMS Existing voluntary reporting of Member States in the framework of ITS Directive Standardisation deliverables from European Standardisation Organisations & other organisations Services profiled, harmonised and deployed
Reduce barriers and uncertainties to enable large-scale deployment of C-ITS	Level of security issues identified Level of data protection issues identified Level of compliance assessment issues identified	Reporting of security incidents in the CCMS Data protection impact assessments carried out by C-ITS data controllers. Reporting of compliance issues by MS to the Commission.
Provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models	Level and effectiveness of EU funding provided for C-ITS development and deployment Level and effectiveness of coordination mechanisms	Commission reporting (based on project reporting) Deliverables of stakeholder platform MS and industry reporting set up of C-ITS bodies to the Commission