C-ITS platform PHASE II

Cooperative Intelligent Transport Systems
towards **Cooperative, Connected and Automated Mobility**

FINAL REPORT
SEPTEMBER 2017

C-ITS Platform

Final report Phase II

September 2017

C-ITS Platform Phase II
chaired by the

European Commission

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C-ITS Platform

Final report Phase II

September 2017

1. Executive summary

This report is the deliverable of the second phase of the C-ITS platform (July 2016 – September 2017) which further develops a shared vision on the interoperable deployment of Cooperative Intelligent Transport Systems (C-ITS) towards cooperative, connected and automated mobility (CCAM) in the European Union. This includes making tangible progress towards the definition of implementation conditions for topics already discussed during the first phase[1], but also recognizes and further investigates the mutual benefits that future C-ITS services will bring in terms of automation. All members of the C-ITS platform believe that the ultimate goal is the full convergence of all developments under Cooperative, Connected and Automated Mobility (CCAM), making use of the digitisation of transport.

In 9 working groups, the C-ITS Platform developed policy recommendations and proposals for action for the Commission as well as other relevant actors along the C-ITS value chain. The first set of outcomes of the second phase of the C-ITS Platform addresses the common technical and legal framework necessary for the deployment of C-ITS and is grouped under section Phase I continued – support for deployment of C-ITS. The second set of outcomes focuses on CCAM, i.e. they explicitly also take the needs and possibilities of higher levels of automation into consideration, and are grouped under section Beyond C-ITS, towards Connected, Cooperative and Automated Mobility (CCAM).

1.1. Delegated Act under the ITS Directive

The ITS Directive 2010/40/EU adopted in August 2010, and its subsequent already adopted Delegated Regulations, for instance on road safety, real-time-traffic and multimodal travel information, provides the necessary legal and technical framework to steer and ensure the interoperability of deployed ITS services.

In order to ensure legal certainty for the investors and set the right framework conditions for the development and implementation of cooperative systems, the co-legislators also identified a specific priority on this topic in the ITS Directive, i.e. on specifications and standards for aspects related to the exchange of data or information between vehicles or between vehicles and infrastructure.

The need for such specifications, in the form of Delegated Act(s), has again been highlighted in the Commission Communication adopted on 30 November 2016[2], with expected provisions on the continuity of services, the security of communications, the practical implementation of data protection rules, a forward-looking hybrid communication approach, rules on interoperability and compliance assessment processes. The Delegated Act(s) will

[1] https://ec.europa.eu/transport/sites/transport/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf

[2] A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility, COM(2016) 766 final

need to set up the necessary legal and technical framework to guarantee the interoperability of all C-ITS deployment for vehicle-to-vehicle as well as vehicle-to-infrastructure services.

During phase II of the C-ITS platform, the Working Groups on Security, Data Protection, Compliance Assessment and Hybrid Communication have all worked on issues that are essential to the interoperability of C-ITS deployment and hence relevant for the preparation of the Delegated Act(s) on C-ITS.

1.2. Phase I continued – support for deployment of C-ITS

C-ITS Security

In order to work towards the deployment goal for C-ITS services in Europe by 2019, shared by Member States and (automotive) industry, certainty on the envisaged C-ITS security solutions needed to be found. Based on the agreement of the first phase of the C-ITS platform that common rules and policies are needed for, and applied by, all public and private stakeholders in Europe the second phase of the C-ITS platform concentrated on delivering the concrete policy documents for C-ITS security. As a concrete outcome of the work in the C-ITS platform, the Commission has published the first version of the European C-ITS Certificate Policy on its website in June 2017.

The working group also worked on the security policy as well as the overall governance framework for deployment and operation of European C-ITS and the publishing of a first version of that document is expected soon. The agreement on those policy documents required a lot of effort and compromises between the public and private C-ITS stakeholders in Europe, but now enable a stable framework to commence with the commercial introduction of C-ITS in Europe by 2019. To this end, it is recommended by all stakeholders that the Commission services should take over an active role in implementing and operating central C-ITS security functionalities for all stakeholders in Europe. All details of the results of the Working Group on Security can be found in section 3.

C-ITS Data protection and privacy issues

The working group on data protection and privacy continued the analysis on the implications of the General Data Protection Regulation on C-ITS. The main focus of the group was to find a solid legal basis for processing personal data in the context of C-ITS taking into account that the legal environment will soon be changing due to the application of the General Data Protection Regulation as of May 2018. The group concluded that the preferred solution in the long-term should be based on a legal obligation where processing of data is necessary for the performance of a task carried out in the public interest.

In order to have a European-wide interoperable system, an enactment of an EU-legal instrument is needed. In parallel with developing the legal framework at European level, the working group recommends that a Data Protection Impact Assessment in accordance with the GDPR is conducted, including the assessment of risks, indicators, methodology for indicators and further requirements for data protection by design.

As the enactment of an EU instrument will require time, and the goal is to start deployment of C-ITS in 2019, the group thoroughly discussed which legal basis could be used during a transitional phase until an EU instrument has been enacted, namely concentrating on consent and on the performance of a contract. The latter was considered to be a solid legal basis, but there are several legally controversial issues related to the implementation and this solution is not considered possible in the short-term. Alternatively, the group is of the view that work should continue to analyse whether technical obstacles to the use of consent as a legal basis could be mitigated to a level that would guarantee a sound level of data protection and privacy.

The working group produced a document on "protection of personal data in the context of C-ITS", to get more guidance from Article 29 Working Party on how to proceed in the future and guarantee a sound level of data protection. Article 29 Working Party is likely to issue its opinion in the beginning of October 2017.

C-ITS Compliance Assessment

The aim of the work on Compliance Assessment was to define a top-level approach and methodology for testing and validation. This included evaluating and issuing recommendations on how this compliance assessment can be achieved, with a specific focus on C-ITS stations, and on the necessary legal and organisational frameworks for the setup and the operational phase of the C-ITS network.

The main recommendations were the following (see detailed recommendations in section 5:

- the need for a common EU legal and technical framework to implement the proposed roles, requirements and processes.
- the need for a progressive approach to allow for deployment in a short timeframe and the need for the capability to introduce in the future new services and/or new technologies in a backward compatibility manner with already deployed services.
- the need to finalise by second half of 2018 the standards and profiles necessary to support the compliance assessment process for Day 1 services.
- the need to further work on the common definition of roles covering all aspects of C-ITS (in particular compliance assessment, privacy/data protection, security) and to maintain consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure.

The following figure summarises the compliance assessment process, the different roles and their interactions:

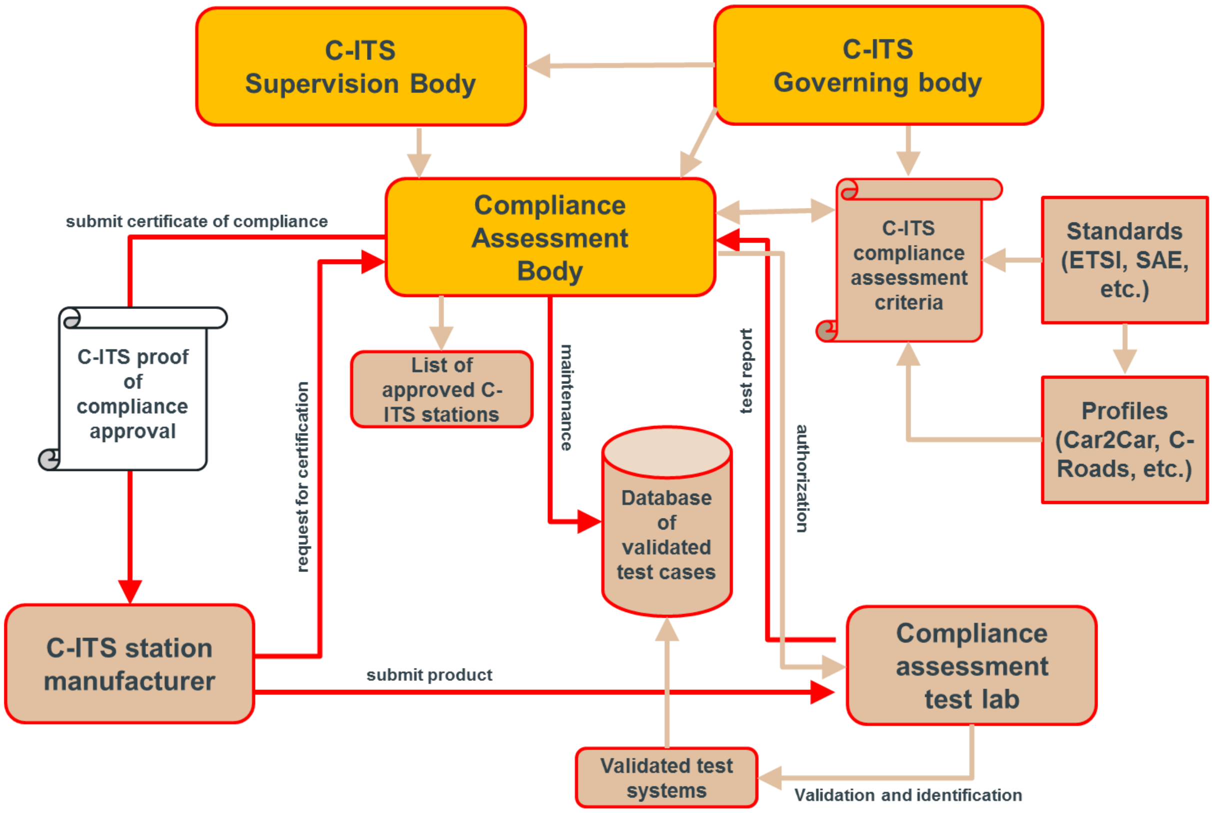

Figure 1: Overview of the compliance assessment process

Hybrid communication

Hybrid communication, making use of complementary communication technologies for C-ITS use cases, has been one of the key principles for European C-ITS deployment, endorsed in the first phase of the C-ITS platform, as well as communicated by the Commission in its C-ITS strategy COM (2016) 766 for C-ITS deployment in Europe. European C-ITS deployment initiatives, notably all initiatives united in the C-ROADS Platform[3], are already deploying based on this hybrid communication approach.

Only one meeting of the Working Group on Hybrid Communication has been conducted in the second phase of the C-ITS platform – hence no particular recommendations are formulated in this report.

Nevertheless, the experts that participated in this working group agreed the potential of CCAM to reduce the 26.000 fatalities claimed every year by Road Transport is one of the driving forces behind these developments and one on which no compromise is possible. This implies that all vehicles need to be able to communicate with each other and with the infrastructure, and that there is a strong need for backwards interoperability. A need, which

[3] www.c-roads.eu

can be considered even more important in the automotive sector, as a typical vehicle has a considerable longer lifetime than electronic consumer devices. Exactly how this backwards interoperability will be achieved is still to be defined by all involved stakeholders but the following **four guiding policy principles** shall be followed at the EU level:

1. Uncompromised safety services for all users in case of multiple technologies implementation; (in compliance with the European C-ITS Strategy COM(2016)766);
2. Technology neutrality of spectrum use (such as in the 5.9 GHz band for safety-related applications, pursuant to Commission Decision 2008/671/EC);
3. Efficient spectrum use (an overarching principle of Union's Radio Spectrum Policy, also encompassed in the provisions of the Radio Equipment Directive 2014/53/EU);
4. Introduction in the longer-term of 5G[4] for the further development of CCAM (s. Rome Letter of Intent of Member States[5]).

Urban C-ITS

Europe is home to many hundred small, medium and large cities and whilst they all have their own unique characteristics, they share a common challenge of how to address growing urbanisation. This is putting an increasing strain on existing urban transport networks resulting in worsened congestion and pollution and ultimately negatively affecting the daily life of their citizens.

The objective of C-ITS is to make road traffic safer and more efficient but in an urban context this is only one piece of a broader puzzle to build an integrated and more sustainable urban mobility system and in particular facilitating modal shift to public transport and active modes. The deployment of C-ITS in urban areas must therefore support strong local policy objectives and demonstrate how it can improve and build on top of existing ITS investments for all road based transport modes. The Working Group identified a number of underlying political, financial, technical and operational barriers and C-ITS specific barriers, which, if unaddressed, would delay the timely deployment of C-ITS systems.

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[4] COM(2016) 588 5G for Europe: An Action Plan: "*Where appropriate 5G will operate in seamless co-existence with technologies already being deployed, in particular short-range communication for vehicle-to-vehicle and vehicle-to-infrastructure (ITS-G5), under a complementarity principle.*"

Accompanying Staff Working Document SWD(2016) 306 - 5G for Europe: An Action Plan: "*In the case of connected vehicles, it is not envisaged that 5G would simply supersede earlier investments in ITS-G5 technology, as currently deployed in Europe and in other regions of the world. This technology is based on an evolution of the WiFi standard (802.11.P) and is recognised as a technology of choice for early ITS deployment in Europe, as outlined in the C-ITS platform final report, targeting primarily road safety services in the first instance*."

[5] This letter sets out ensuring “complementarity and co-existence with existing communication technologies such as ITS G5 and LTE".

Ultimately, urban stakeholders will choose which C-ITS services can best address local problems and bottlenecks but as deployment comes with a cost it must be fully suitable and effective in the urban environment and demonstrate it can directly benefit the citizen. In this context the need to widen the scope of C-ITS services to more urban specific use cases was recognised. As such, new C-ITS services and extended functionality or user groups of existing Day 1 and Day 1.5 services were identified by the Working Group.

A number of dedicated urban C-ITS projects and initiatives, at both national and European levels, have produced valuable results and fostered exchange of best practises. However, further Urban C-ITS research and pre-deployment testing and Urban C-ITS standardisation initiatives will be crucial in the near future. To address this and to guide such developments a number of specific recommendations have been identified by the Working Group. Notably the need to demonstrate the benefit of C-ITS in a complex urban environment with a wider range of transport modes and urban C-ITS services with the full chain of urban stakeholders is essential. Standardisation activities, notably within the Urban ITS Standardisation Mandate that facilitate interface interoperability, multi-vendor integration and urban C-ITS service harmonisation, are also crucially important.

The deployment of C-ITS services in urban areas across Europe will require the involvement and support of a wide range of public and private actors all of which have unique roles and responsibilities. In particular, both Member States and the European Commission have a role to enable the appropriate financial and technical support to facilitate C-ITS deployment. European Industry and standardisation organisations need to work closely with local authorities to better understand their needs and requirements. C-ITS initiatives and platforms must ensure the active participation of local authorities and future projects and deployment activities must address the defined research requirements. Local authorities and the public transport sector have a responsibility themselves to define their own C-ITS deployment strategies and engage with C-ITS stakeholders to define how C-ITS can best support their sector and local context.

Business Models

The deployment of C-ITS cannot rely on public funding alone and requires the involvement of stakeholders from different industries and the public sector. To give sufficient confidence to the core stakeholders to invest, the decision to deploy Cooperative Systems has to be based on sound and convincing business cases for all the actors along the value chain.

The cost-benefit analysis carried out in the first phase of the C-ITS Platform clearly showed that the potential benefits of C-ITS strongly outweigh the costs, but also that these benefits will only materialise over time, and depend strongly on coordinated and accelerated deployment.

Also, a large part of these 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.

It is clear that initially, as it is focusing firstly on safety applications, the C-ITS market is not yet truly a mature and independent market that can operate without governmental support, until additional commercial applications can build on deployed C-ITS equipped vehicles and infrastructure. Also, the transition of C-ITS services from the testing phase to large scale commercial deployment needs to be supported to bridge the initial gap.

A sound and shared (common understanding of a) business model for C-ITS is thus needed, which reduces uncertainties on which value is created for all stakeholders that are expected to invest.

The Working Group aimed to:

- Raise awareness on different business models for C-ITS services
- Investigate interest in, and mutual understanding of, business models
- Explore process for creating a business model for the C-ITS eco-system
- Identify barriers and / or issues that need addressing

To support the business model analysis and identify key motivations and issues for each stakeholder group in deploying C-ITS, the Working Group developed a description of C-ITS business models from various stakeholder perspectives. Based on the individual perspectives, the Working Group then identified a consolidated list of key motivations and issues for each stakeholder group in deploying C-ITS.

Based on this analysis the following recommendations were developed:

- All C-ITS deployment projects and pilots should be encouraged, and where possible required (such as in EU or national co-funded projects), to report on the costs, impacts and benefits of the C-ITS services piloted and deployed. A separate action is needed to compile the cost, impact and benefit data produced by these projects, and to provide a synthesis of the results including their transferability to different conditions and environments.

- A governance layer of C-ITS should be formed, responsible for policy setting, shared aspects of service operation and "system" supervision. The elements of the governance layer bring with them development and common costs which are to be shared by the actors. These costs need to be estimated. Data needs to be gathered, both within and outside projects, keeping track of the parties and activities incurring these costs. The results should be used in the refinement of business models.

- C-ITS (and cooperative, connected and automated mobility) hinges on data. The data are owned or governed by a number of different stakeholders. Access to all relevant data will facilitate not only C-ITS services but also a number of other services, with considerable economic value. An agreement on access to data between all relevant public and private stakeholders should be found, including business model-related questions of national or European data licenses, formats, interfaces, addressing privacy concerns etc.

- Established quality levels limit potential risks to all parties in their business models. Data provided to National Access Points and in-service delivery should have an agreed (minimum) level of quality.

1.3. Beyond C-ITS, towards Connected, Cooperative and Automated Mobility (CCAM)

Urban Automation

Across the EU, at least 12 Member States have facilitated the testing of highly automated vehicles on public roads. In parallel, technological developments have rapidly progressed meaning highly automated vehicles across different modes are ready to be tested and piloted. For cities across the EU, the potential arrival of automation raises the prospect of safety issues, increased traffic and consequently worsened pollution and congestion if not tailored and shaped towards the needs of local authorities. Before automated vehicles are commercially available and while the legal framework is not yet finalised, there is a window of opportunity for local authorities to plan how automated vehicles will be managed and operated in their city, otherwise they face the prospect of the technology arriving when they are not ready and prepared. However, the technology itself is not the prime concern of local authorities but actually the **mobility services** themselves that they can offer.

Local authorities have a range of possibilities in shaping how automated vehicles can operate in their city, but to properly and effectively prepare, local authorities need a clear and realistic timeframe of when automation will arrive. However, at present there is no commonly agreed view amongst all urban and industry stakeholders of when automation will arrive, which therefore makes it difficult for local authorities to effectively and confidently conduct such planning. Nevertheless, at this point in time a number of important activities can be envisaged:

- Demonstrate to industry stakeholders how automation should be used to support integrated and sustainable urban mobility through optimal and sub-optimal use cases
- Identify which tools and enablers can be used by urban stakeholders to influence the operation of automated vehicles and what they need to prepare for
- Ensure the complementary of Urban C-ITS deployment and higher levels of automation

Road safety issues

A qualitative assessment was made aiming at identifying road safety issues that need to be addressed in relation to the deployment of Day 1 and Day 1.5 C-ITS services and the Working Group recommended some actions to authorities and stakeholders.

The aspects addressed in this assessment are the following:

- Priority C-ITS services from a safety point of view.
- Technical issues.
- Human Machine Interaction
- Driver behaviour
- Traffic rules

The group concluded that some 'Day 1' and 'Day 1.5' C-ITS services can provide significant safety benefits and therefore their deployment should receive full support; the group agreed upon recommendations on support actions for the European Commission, authorities and stakeholders.

The group agreed as well on recommendations for further progress in the development and deployment of C-ITS services, in particular it recommended measures aimed at improving the Human Machine Interface. It is also recommended to integrate driver behaviour considerations in the conception of C-ITS services, taking into account the possibility to adapt traffic rules, allowing for a consistent use of C-ITS services across the EU.

Physical and Digital Infrastructure

Exactly how physical and digital infrastructure will evolve and support CCAM is not clear at this point. This is related to the fast technological developments and the uncertainty to what is achievable – at reasonable cost – with on-board sensors and data processing. Nevertheless, regardless of where the future balance will lie between vehicle capabilities and infrastructure support it is well understood by all that a certain level of redundancy between the two is very welcome. Road infrastructure is also expected to play a role in delivering the high positioning accuracy and reliability required by CCAM. This includes investigating the needs for landmarks, in particular in temporary work zones and other higher risk road sections. This leads to the realisation that a true (ubiquitous) SAE level 5 vehicle may not be possible (as comprehensive infrastructure support will likely never cover the entire road network).

In addition, there is no doubt that digital infrastructure will significantly gain importance and will greatly support connected and automated vehicles and other road users into understanding their surroundings. Hence, to enable efficient data exchange between vehicles and fully exploit the support from digital road infrastructure, ***automated vehicles***

shall be cooperative and connected vehicles. The cooperative and connected elements will allow vehicles to receive, in real-time, in addition to the digital knowledge of the infrastructure already available in the vehicle (e.g. digital maps), key attributes of roads relevant for automated driving, with the aim of adding predictability on what to expect on the road ahead and enlarging the decision base for using automatic mode. The cooperative element is required, amongst others, to handle complex traffic situations. To go beyond awareness – realised by the Day 1 & Day 1.5 C-ITS services defined in the first phase of the C-ITS platform – a new set of technology agnostic C-ITS messages for collective perception needs to be standardised. This means that future vehicles will share what they see and all vehicles in range will see what they see collectively. To make this work a common operational environment for sharing such messages will need to be developed, including the context and the interpretation boundaries (such as the quality assumptions to quantify trustworthiness, precision, timeliness and reliability of information) for the receiving vehicle.

As support from the digital infrastructure increases, so does the need to ensure consistency between the physical and the digital infrastructure. Increased requirements in terms of Quality of Service and Functional Safety needs imply a need to investigate their (regulatory) consequences with respect to information sharing. A clear legal framework – including traffic regulation – will also be essential to avoid (new) conflicts between information coming from physical and digital infrastructure, and establish precedence regarding information. Finally, as a starting point to further develop the digital infrastructure, it is recommended that all actors that possess, control or own data need to work on the accelerated and joint implementation – by public and private stakeholders – of existing and future Delegated Acts under the ITS Directive. All actors are encouraged to apply fair conditions for sharing data, taking into account the costs related to transforming raw data into useful (traffic) information.

Enhanced Traffic Management

Today, OEMs and Service providers' nomadic devices offer navigation and routing advice. In the future, the data collected with cooperative, connected and automated systems will grow in volume, thus improving the quality of navigation services. These services will have a big influence on traffic behaviour.

However, in order for cooperative, connected and automated systems, to produce the expected collective benefits in terms of road safety and traffic flow efficiency, alignment with the public sector is required.

Combining the data from private and public stakeholders will enhance Traffic Management and enable enriched traffic forecasting capabilities. Such data includes planned events (e.g. Road Works, bridge or tunnel circulation restrictions) and temporary measures (Traffic Management Plans or Traffic Circulation Plans). Furthermore, the group agreed that to provide context, traffic regulations (static or dynamic; mandatory or advised) also need to be digitalised and become 'electronic regulations'. Traffic managers will therefore need to translate their traffic management policy (TMPs and TCPs) into a *digitalised standardised language*, so that it can be exchanged with the other stakeholders and become much more effective.

The group agreed on the need to encourage public and private cooperation and data sharing, but also recognised the slightly different perceptions of the cooperative benefits by public and private stakeholders. As the private sector understandably focuses on their customers, developing added-value services and commercially well-defined business models, an agreement with Public Authorities on how they will share the responsibility of managing traffic is needed.

The trade-off for improving traffic flow efficiency with CCAM, needs to take into account the individual user needs together with the collective's best interest.

In order to cope with more complex and more flexible scenarios, and taking into account the long period of mixed traffic conditions, expected far beyond 2019, the group concluded that Traffic Management should move from centralized to more decentralized or distributed governance models. Therefore, Cooperative Traffic Management Services need to be developed under a clear governance framework, in order for Public authorities to preserve their role, without compromising the commercial competitive advantages of Services Providers and OEMs.

The added value of collaboration was then clearly defined; Traffic Managers can expect a higher compliance with the traffic measures they issue, as connected and automated vehicles will certainly follow them to a higher degree than non-connected vehicles. From the *vehicle's* perspective, manufactures and service providers aim to achieve a better understanding of those traffic measures, in order to provide improved and more resilient mobility services.

After a long and very fruitful discussion, encompassing both the establishment of a common strategic approach with the operational setting-up of practical initiatives towards the deployment of Pan-European rollout of Cooperative Traffic Management Services, the group concluded on the need to define the first steps:

- To develop the building blocks for <u>digital</u> Traffic Management Plans, Traffic Circulation Plans and the deployment of Cooperative Incident Management. These building blocks shall be modular, scalable, replicable and compliant with standards.
- To develop a repository of digital TMPs and TCPs, available via the National Access Points. The repository shall be the outcome of a joint effort from both the private and public sectors.
- To start piloting digital TMPs, TCPs or their building blocks, in the comprehensive TEN-T Road Network, including urban nodes.

- To make available funding instruments (CEF, H2020) taking into account the research and piloting recommendations and start the roll-out of Pan-European enhanced traffic management services along the comprehensive TEN-T corridors including urban nodes.
- To develop a set of tools for the deployment of Pan-European Cooperative Traffic Management Services, while ensuring their interoperability across borders, cities and brands.

1.4. Conclusion

As announced in the European strategy on Cooperative Intelligent Transport Systems[6] - and confirmed by public statements of the automotive industry[7] and sizeable investments from Member States, united in the C-ROADS Platform[8] - the 2019 target for large-scale C-ITS deployment is now becoming a reality. To progress towards this shared goal important work on security, data protection and compliance assessment is required and key advances in these areas were achieved during the second phase of the C-ITS platform, also **providing valuable input to forthcoming work on future Delegated Act(s).** The most notable example was the publication of the first version of the European C-ITS Certificate Policy as an outcome of the work in the C-ITS platform on security in June 2017.

Achieving the 2019 target is not only vital to counter the stagnating trend in road safety but also in making tangible advances in traffic efficiency, reducing the emissions from transport and increasing the sustainability of future mobility solutions. Furthermore, this is vital for the competitiveness of the **European industry**, which is at the forefront of this evolution and has real opportunity to be the **first to deploy C-ITS** and **lead on CCAM globally**. Finally, we recall a recommendation from Phase I to further increase awareness and knowledge on C-ITS to maximise the impact of the 2019 roll-out (e.g. road planners should be supported to take this evolution in to account).

Though all work under the C-ITS flag has relevance for the expanded scope of CCAM, several working groups expanded their scope and explicitly considered automation, in some cases even dominating the discussions. For example, when discussing the **key attributes of roads in support for automated driving** (discussed in the Infrastructure and Traffic Management Working Groups) or considering the role of automated vehicles in urban mobility. In this respect, we also highlight the important work performed under the GEAR 2030 platform, which will publish its final report on 18 October 2017, and which complements the recommendations from this report with an additional focus on automation, thus further completing the CCAM picture.

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[6] COM (2016) 766 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2016%3A766%3AFIN
[7] E.g. the press release of the Car2Car consortium and a press release of Volkswagen
[8] www.c-roads.eu

The C-ITS platform members are calling on the European Commission to build on these conclusions and outputs to, actively and without delay, guide the interoperable deployment of CCAM in the EU with clear timelines, goals, objectives and actions. Though remaining actions directly targeted at meeting the 2019 deployment goal are clearly in the implementation phase, the vision on what comes afterwards is far from complete at this stage. The Platform Members are therefore calling on the European Commission to continue building that vision – as was done successfully for C-ITS so far – by clearly **expanding the scope of the stakeholder platform to all aspects related to CCAM**.

This report of the second phase of the C-ITS platform has been endorsed by nominated experts, representing the organisations and countries listed in the Register of Commission Expert Groups[9]. On an ad hoc basis, individual experts have been invited to participate in the work of specific working groups and are listed in the attendance list of each working group.

2. The C-ITS platform – Objectives and process

The Platform for the Deployment of Cooperative Intelligent Transport Systems in the European Union (C-ITS Platform) was launched by the Commission in July 2014, and met for the first time in November 2014. The C-ITS Platform was created with the clear intention to support the emergence of a common vision, provide an operational instrument for dialogue, exchange of technical knowledge and cooperation on technical, legal, organisational, administrative and governing aspects. The C-ITS Platform represents all the key stakeholders along the value chain including the Commission, public stakeholders from Member States and local or regional authorities, road operators, vehicle manufacturers and suppliers, service providers, telecomm companies etc.

The objective of the C-ITS platform is to identify and agree on how to ensure interoperability of C-ITS across borders and along the whole value chain, as well as to identify the most likely and suitable deployment scenario(s). These include the first vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) services to be deployed across the EU and their most beneficial geographical environments (long distance corridors, secondary roads and the urban environment) and remains valid for all future developments in CCAM.

After a first Phase of the Platform which led to the adoption of a final report in January 2016[10], these topics were further analysed and discussed in the second phase of the Platform (July 2016 – September 2017) in 9 working groups, gathering around 200 experts[11] on a monthly basis. Those working groups were all chaired by DG MOVE representatives in

[9] http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3188
[10] https://ec.europa.eu/transport/sites/transport/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf
[11] http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3188

cooperation and with active participation of other Commission services, such as DG JRC, DG GROW, DG RTD, DG CNECT, DG JUST or institutions such as the European Data Protection Supervisory (EDPS). Additionally, three plenary meetings of the C-ITS platform were organised in December 2016, June and September 2017. All working groups developed policy recommendations and proposals for action (for the Commission but also for other relevant actors along the C-ITS value chain), endorsed by the C-ITS platform during its plenary meeting on 20 September 2017, which formally concluded the second phase of the platform.

All following sections of this report discusses in far more detail the work performed in the different Working Groups of the C-ITS Platform. To better understand the sequence and interaction of these descriptions Working Groups were grouped into two large parts, the first dealing with the continued support for the deployment of C-ITS and the concrete actions that are needed to enable large scale deployment in 2019, including input to a new Delegated Act under the ITS Directive. The second part focusses on what comes after the first wave of C-ITS deployment, the impact of automation and how both will merge into CCAM.

2.1. Phase I continued – support for deployment of C-ITS

This part includes Working Groups which have already been active during phase I of the C-ITS platform, and continued their work during phase II to define the framework conditions for the deployment of C-ITS.

The Working Groups on security, data protection, compliance assessment**,** hybrid communication, and business models have accomplished their work with a view to completing the legal and technical framework necessary for the deployment of C-ITS. This can be considered a follow-up of the elements already defined during Phase I of the C-ITS platform, including aspects which may be taken up by the upcoming delegated act under the ITS Directive, and for the Working Group on Urban areas with the objective to investigate specific urban challenges related to the introduction of C-ITS and automation.

2.2. Beyond C-ITS, towards Connected, Cooperative and Automated Mobility

As stipulated in the European strategy on Cooperative Intelligent Transport Systems[12] C-ITS and automation belong together and shall converge to cooperative, connected and automated mobility (CCAM) in order to have the highest benefits in terms of road safety and efficiency. Hence, Phase II of the C-ITS Platform aimed at discussing the implications of higher levels of automation in C-ITS services. In particular, work items have been defined to analyse the implications of higher levels of automation in terms of the physical and digital

[12] COM (2016) 766 - http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2016%3A766%3AFIN

road infrastructure, enhanced traffic management and the associated road safety issues. Furthermore, the specific aspects of CCAM in the urban context have been discussed and are summarised in this part.

I - Phase I continued – support for deployment of C-ITS

3. Working Group - Security

3.1. Introduction

3.1.1 Scope of Work

The second phase of the C-ITS platform on the topic of C-ITS security concentrated on the implementation of the recommendations that have been agreed upon in the Phase I report of the C-ITS Platform from January 2016. The joint objective of all stakeholders was to find viable solutions how to ensure secure and trusted communications of messages being exchanged between vehicles and between vehicles and the infrastructure. The final report of the first phase of the C-ITS platform included a very detailed analysis of the different options for the implementation of a **trust model** in Europe to ensure **secure and interoperable exchange of C-ITS messages** on an EU-wide level. In practice, roles and responsibilities have been identified as well as a number of criteria that need to be met. 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. This is reflected in the definition of a **European Union C-ITS Security Credential Management System (EU CCMS)** for C-ITS messages.

The implementation of an EU CCMS is urgently needed for European C-ITS deployments (e.g. through the C-ROADS platform, which harmonises real-life deployment activities in Member States or the Car2Car Communication consortium), both in a first learning and testing phase as well as for any commercial large-scale market introduction.

Hence, the primary focus of the activities of WG Security in Phase II of the C-ITS Platform lied on the formulation and agreement of two important documents to enable secure and interoperable C-ITS Day Service deployment in Europe:

- **C-ITS Certificate Policy for Deployment and Operation of European C-ITS:** defines the details on the roles and processes how security certificates are issued to define a common level of trust in C-ITS messages in Europe.

- **Security Policy & Governance Framework for Deployment and Operation of European C-ITS:** defines additional cyber security requirements and defines who is concretely taking over which role in the C-ITS overall scheme including security.

3.1.2 Organisation of Work

From the beginning of 2016, the C-ITS platform activities on C-ITS Security (WG Security) were focused on the implementation and deployment aspects of C-ITS in Europe. The organisation of work was based on regular Working Group meetings in Brussels and conference calls from January 2016 to September 2017 in the course of the second phase of the C-ITS platform and also on numerous phone conferences and meetings to deal with specific sub-topics and to directly edit the respective documents.

All results, outputs and expert recommendations of the C-ITS Platform Working Group Security have been prepared and discussed by the nominated experts representing the organisations and countries listed in "*C-ITS Platform Phase II Annex I WG Participant Lists",* annexed to this report. This report of the C-ITS Platform Working Group Security has been approved by the Working Group on the 4th of September 2017.

3.2. C-ITS Certificate & Security Policy

Several workshops have been conducted in the C-ITS Platform to write the actual documents and to achieve the necessary consensus among all involved C-ITS Stakeholders (e.g. Member States and public authorities, automotive industry, suppliers, etc.). The group has reached a crucial milestone in June 2017 with the agreement on the first version of the common certificate policy by all involved public and private actors.

The current version of the *C-ITS Certificate Policy for Deployment and Operation of European C-ITS* is available on the Website of the European Commission at:

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

The current version of the *Security Policy & Governance Framework for Deployment and Operation of European C-ITS* is expected to be published still in 2017 on the same Website.

Please note that while the first version of this document is drafted in the C-ITS Platform, it is important to mention that it is foreseen that the documents will be maintained and updated through specific roles (e.g. an "C-ITS Certificate Policy Authority") that need to be setup on EU Level. According to the common C-ITS Certificate Policy this top level “Policy Authority” governance body is expected to be a role composed of the representatives of public and private stakeholders (e.g. Member States, Vehicle Manufacturers, Road Infrastructure Operators, European Commission, etc.) participating to the EU CCMS. The Policy Authority is hence the governance body responsible for the approval and maintenance of the certificate policy document. It is foreseen that, once C-ITS has been deployed, the evolution of the technologies and cryptographic algorithms as well as the evolution of risk likelihood and impact may trigger request for changes in such documents. The Policy Authority has the responsibility to manage these change requests and update the relevant documents if needed. In addition, the Policy Authority has other responsibilities in the EU CCMS, which are defined in the certificate and security policy documents.

3.3. Considerations on C-ITS Security Governance Structure

This section summarises some of the main elements of the envisaged governance structure that is described in more detail in the certificate & security policy documents and served as basis for some of the recommendations of C-ITS Platform WG Security that have been identified in section 3.4

Extensive discussions took place in the C-ITS platform WG Security on the different options regarding the possible governance structures. What has been clear already following the first phase of the C-ITS platform is that European stakeholders do not want a fully centralised system where all roles would be controlled through a central body (this is e.g. the case in the US for a proof-of-concept pilot operation). The chosen model therefore allows both public and private entities to set up "Root Certification Authorities" (Root CAs). These are responsible for issuance of security certificates and revocation of the same certificates under the conditions established in the common EU certificate policy that applies to all entities participating in the C-ITS trust model. The definition of common policies is needed to ensure interoperability among the European C-ITS stations (e.g., vehicles or infrastructure stations) which will be enrolled and authorized under different root CAs.

However, this distributed system design still demands some **central coordination role** in Europe. The coordination at European level is needed to ensure that at all times a consistent list[13] of all valid and running Root CAs in Europe is maintained and distributed to all involved parties – this is an essential requirement and the only way that the distributed Root CA approach can work in an interoperable and secure way across Europe. The discussion in the Working Group resulted in a proposal that this coordination role could in a first phase be taken over by the Commission as a neutral and impartial body recognised by both industry and the Member States. This role is needed both in a first learning and testing phase as well as for any commercial large-scale market introduction in the future.

The trust model governance architecture is composed of the following roles:

EU Coordination Role: Trust List Manager (TLM) and C-ITS Point of Contact (CPOC):

The architecture is composed by a set of root certification authorities (root CAs) "enabled" by the Trust List Manager (TLM). The TLM is a unique centralised role in Europe and is mainly responsible for maintaining a list of all operational root CAs (operated by either public or private entities) in Europe – this list is called the "European Certificate Trust List" (ECTL). The TLM issues this list that provides trust in the approved European root CAs to all participants of the C-ITS system.

[13] Later referred to as "European Certificate Trust List - ECTL" – a List of all entries of existing Root CAs in Europe

Since the C-ITS trust model is based on a multiple root CA architecture, the role of a C-ITS central point of contact (CPOC) is also needed to periodically receive information from the participating root CAs via secure communication. The CPOC role has a close link to the TLM role and takes over operational security functions such as the certificate verification of root CA certificates and the publication of the ECTL.

Both the TLM and the CPOC are unique entities in Europe appointed by the Policy Authority. C-ITS Platform WG Security proposes that **these centralised unique roles of the TLM and CPOC shall be taken over by the Commission as an impartial neutral body recognised by all Member States, industry representatives and other involved stakeholders**. These roles are needed for coordination of all stakeholders that deploy C-ITS and interoperability of C-ITS in Europe and shall hence be operated by the Commission.

EU Root Certificate Authority (EU Root CA):

In general a root CA can be operated by a governmental (i.e. European Member State) or a private organization since the European C-ITS platform has chosen a public-private model for the deployment of the EU CCMS, which is based on a distributed architecture. However, in order to guarantee the functioning of the C-ITS security scheme with a high level of availability, there is a need that at all times at least one root CA is available in the C-ITS trust model architecture. Therefore, an EU root CA shall be provided to all the entities participating to the C-ITS trust model and which do not set up their own root CA. This is especially needed in the start-up phase of the C-ITS trust model to ensure that C-ITS deployment initiatives (e.g., gathered under the C-ROADS platform) can test and operate their initial deployment in an interoperable manner. The Working Group Security of the C-ITS Platform proposes that **the set-up of the EU Root CA shall be started by the Commission as an impartial neutral body recognised by all Member States and industry representatives,** but the actual operation of the EU Root CA could be the contracted responsibility of a commercial company. The sub-CAs of the EU root CA (Enrolment Authority and Authorization Authority) could also be run by contracted entities.

There is broad agreement from the European Member States and the industry representatives on the urgent need to setup the common European elements within the EU CCMS (i.e., CPOC, TLM and EU Root CA at European level) and that the Commission services could implement these roles. As noted in the C-ITS Strategy COM 2016/766 the Commission already takes an active role in similar systems, like for instance for the Smart Tachograph where parts of the trust model (e.g., European Root Certification Authority) are operated by the Commission.

3.4. Recommendations

The following recommendations have been agreed upon in Working Group Security in Phase II of the C-ITS Platform:

- It is recommended that the EC continues to steer the elaboration and updating of the common European C-ITS certificate and security policy together with all relevant C-ITS related stakeholders.
- It is recommended that the EC sets up a financed pilot phase at least until 2021 of the common European Elements CPOC, TLM and EU Root CA (incl. EA, AA) to enable initial C-ITS deployment in Europe for all stakeholders.
- It is recommended that the EC should analyse how to best embed the common European certificate and security policy in the envisaged C-ITS Delegated Regulation under the ITS Directive 2010/40/EU.
- It is recommended that the roles and legal entities defined in the Certificate Policy and Security Policy & Governance Framework documents need to be implemented on European level as soon as possible, but at the latest in 2019.
- It is recommended that further work should be done to link the C-ITS security framework to an overall C-ITS compliance assessment process, including data protection and efficiency. One important element of this logical link is the definition of the protection profiles for C-ITS stations.
- It is recommended that further work should be done towards evaluating possible cross certification of the setup European C-ITS security system with other Root CAs in the international environment / other regions of the world. It is recommended that the European best practices established through the activities of the C-ITS Platform should be promoted to other regions of the world in this context, e.g. through European Standardisation Organisations.
- The following future standardisation needs and/or research topics have been identified:
    - Misbehaviour detection, reporting, enforcement and revocation mechanisms
    - Cryptographic algorithms and crypto agility
    - Authorisation ticket handling to best preserve privacy
- It is recommended that a general harmonisation - going beyond the scope of Working Group Security of the C-ITS Platform – of the results of the three main areas of C-ITS Compliance Assessment, C-ITS Data Protection & Privacy and C-ITS Security needs to be done in order to further exploit synergies and coordinate efforts.

4. Working Group – Data Protection & Privacy

4.1. Objectives of the Working Group

The objective of the C-ITS Platform Working Group on Data Protection & Privacy in phase II was to conduct an analysis of the suitable legal bases for lawfully processing personal data and to analyse the deliverables of phase I against the background of the General Data Protection Regulation (hereinafter GDPR)[14]. This is important, as it had been concluded during phase I that messages broadcast from and to C-ITS equipped vehicles are personal data and therefore the GDPR applies. During phase I, the GDPR was still subject to negotiations both in the European Parliament and Council, the legislative process being finalised in April 2016 and the GDPR being applicable as of from May 2018.

During phase I, the working group had concluded that informed consent would be the appropriate legal basis for lawfully processing personal data in the context of C-ITS. The aim of the working group was to obtain guidance and points to be taken into account from Article 29 Working Party[15] in order to reach a sound level of protection of personal data also in relation to the GDPR. The document "Processing Personal Data in the Context of C-ITS" was submitted to the representative of the technology subgroup of Article 29 Working Party on the 10th of July 2017 with a view to receive an opinion in the beginning of October 2017.

4.2. Organisation of Work

DG MOVE chaired the Working Group on Data Protection & Privacy together with Joint Research Centre (JRC). The organisation of the work was based on 12 face-to-face meetings from 28 of June 2016 to 12 of July 2017 and also several phone conferences were organised. A task force was set up to support the work of the working group to compile an analysis of processing personal data in the context of C-ITS and to contribute towards the document "Processing Personal Data in the Context of C-ITS" and another task force was working on the governance structure.

DG MOVE as chair took care of maintaining relationships with other working groups under the C-ITS platform and informing Working Group on Data Protection & Privacy participants of work items which could be relevant for the group to consider. Especially in relation to the work of the security working group, there were many interlinked issues relevant to both of the working groups. The chair was also in contact with the European Data Protection

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[14] REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)

[15] The Working Party was set up under Article 29 of Directive 95/46/EC. It is an independent European advisory body on data protection and privacy. Its tasks are described in Article 30 of Directive 95/46/EC and Article 15 of Directive 2002/58/EC.

Supervisory Body and DG JUST. The Article 29 Working Party nominated a representative from its technology subgroup to the Working Group Data Protection & Privacy.

All results, outputs and expert recommendations of the C-ITS Platform Working Group Data Protection & Privacy have been prepared and discussed by the nominated experts representing the organisations and countries listed in "*C-ITS Platform Phase II Annex I WG Participant Lists*", annexed to this report.

4.3. Conclusions

4.3.1 Legal Issues

4.3.1.1 Legal basis according to article 6 of the General Data Protection Regulation, lawfulness of processing

The Working Group finds that the preferred solution in the long term for lawfully processing personal data in the context of C-ITS should be carried out in accordance with a legal obligation where processing data is necessary for the performance for a task carried out in the public interest. This processing must have a basis in the European Union or Member State law. As the aim is to have a European-wide interoperable system, the enactment of an EU-legal instrument would be needed.

In that EU-instrument, the general conditions governing the lawfulness of processing personal data would be specified as well as the type of personal data being processed and the data subjects concerned. In addition, the data controller(s) would be determined. It also should be defined in the EU-instrument if the controller performing a task in the public interest should necessarily be a public authority or could also be another natural or legal person. Furthermore, it should take into account the entities to which personal data may be disclosed, the purpose limitations, storage period and other measures that would be needed to ensure lawful and fair processing of personal data in the context of C-ITS. It was noted that the EU-instrument must be proportionate to the legitimate aim pursued.

As the enactment of an EU instrument will require time, and the goal is to start deployment of C-ITS in 2019, the Working Group thoroughly discussed which legal basis could be used during a transitional phase until an EU-instrument has been enacted, namely concentrating on consent and on the performance of a contract.

From a legal point of view, the Working Group considers that performance of the contract (between the data subject and the data controller and between the data controllers themselves) might be an appropriate legal basis. In this respect, the Working Group recognised that the complexity of the contractual relationship in the C-ITS framework as well as the long chain of actors being involved, should be linked to the concept of joint controllership as defined in the article 26 of the GDPR if performance of the contract is to be used as the legal basis in the C-ITS or the consortium acting as a single controller. However, this would require different levels of responsibilities. It also requires an analysis of the various entities in relation to the purposes and means of processing as well as taking into account the principle of accountability and fulfilment of contractual obligations distinct to data processing agreements and an evaluation of how much power is delegated to different actors together with the relationship between the actors.

Therefore, the group believes that for practical reasons, this solution would not be possible to be implemented in the short term. The required set-up of a consortium comprising all C-ITS operators, the development of a governance structure defining each operator's roles and responsibilities and including an effective enforcement mechanism as well as the signature of a contract between the consortium and each individual user appear particularly complex and time-consuming. It appeared that the controller is a constellation of peers, which data subject and controller(s) might not be aware of each other's identities and that data controllers might not have a direct one-to-one relationship with the data subject, due to the open broadcast nature of the data.

The possible establishment of a code of conduct to address some of these issues was considered but equally held not be feasible in time for C-ITS deployment in 2019.

Nonetheless, the Working Group will continue to map out a governance structure in order to facilitate possible later developments with the enactment of the EU legal instrument. Furthermore, the group is of the view that work should continue to analyse whether technical obstacles to the use of consent as a legal basis could be mitigated to a level that would guarantee a sound level of data protection and privacy.

4.3.1.2 Other legal issues

a) The Working Group concluded during phase one that the e-privacy Directive and its transposition in Member States laws is not applicable in the context of C-ITS. However, the working group is aware that a proposed Regulation revoking the Directive on e-privacy was published on the 10th of January 2017.

   The working group believes that clarification is needed regarding the potential application to C-ITS of the proposed e-Privacy Regulation during the interinstitutional process. While this instrument targets the electronic communications sector, it is unclear whether and to what extent C-ITS and in particular cooperative vehicle-to-vehicle communication will be within its scope. This will require additional analysis in the future.

   Recital 12 of the proposed Regulation stipulates that "this Regulation should apply to the transmission of machine-to-machine communications". In its opinion 01/2017, the Article 29 Data Protection Working Party says that "one particular context in which application of the e-Privacy Regulation requires clarification is the area of Intelligent Transport Systems". Considering that the e-Privacy Regulation prohibits the processing of electronic communications data, the opinion goes on to say that "consent from end-users is not a feasible exception because it may become necessary to always be able to process these data. Providers should therefore be able to rely on a specific exception, allowing objects such as self-driving cars and devices to warn each other about their vicinity or other risks."

b) It has been brought up that the data controller would need additional personal information to identify the data subjects in order to be able to satisfy the rights of data subjects as expressed in the GDPR, which in itself would probably violate the 'data minimisation' principle to process the minimum amount of data necessary to fulfil the purpose of C-ITS. In this respect, it has been brought up that Article 11 of the GDPR is likely to apply and would relieve the data controller of his responsibility to give access to data, rectify or erase data, make data portable, etc. unless data subjects makes additional personal data available for the purpose of exercising their rights under the GDPR. Furthermore, it was discussed that from a practical point of view an organisation of data controllers would probably be best suited to assure the mutual recognition of the specification of the 'day-one' applications - the means of processing. At the same time, a guardian of public interest would be required to control if the 'day-one' applications, as specified by the data controllers, meet the purpose of public interest. This organisation would exercise joint control over C-ITS. The group concluded that a data controller model should be drawn up to clarify the responsibilities of the various actors.

c) During the course of the work done in the working group, a full analysis of the implications of the GDPR has not been carried out. It was brought up in the group that when an analysis of that kind is done, it should cover the entire GDPR in order to clarify which other issues than those mentioned in this report should be further analysed.

d) The Working Group also discussed if a model should be further elaborated where individual vehicle receiving data would not be defined as data control when data remains in the vehicle (offline vehicle).

4.3.2 Technical Issues: Data protection by design and default

The risk of tracking has been recognized in the working group as one of the issues that can hamper trust in C-ITS. From a technical perspective a lot of the elements that ensure privacy of end-users are implemented in the C-ITS security scheme, namely through the concept of alternating pseudonym certificates. For European C-ITS deployment this means that this close link between the topics of C-ITS data protection and C-ITS security with the certificate change strategy needs to be duly taken into account to minimize the risk of tracking and tracing.

It was noted in the group that there might be some caveats concerning the so-called transparency by standardization within the context of C-ITS. The transparency provided to users might not be sufficient to deliver to the user the logic and identity behind the processing of his/her personal data and therefore better transparency would be achieved by uniform personal data processing procedures.

Furthermore, the working group sees that from a technical perspective key elements of data processing using privacy by design have been incorporated from the initial design of the C-ITS system: limited range and radius (300 meters), alternating pseudonym certificates to avoid tracking, local 'on the spot' exchange of data between neighbouring vehicles with little data retention and no further processing.

4.3.3 Organisational issues

During the course of the work, a team was working on analysing the allocation of roles and responsibilities of all parties involved in collaborating in Cooperative Intelligent Transport Systems (C-ITS), to establish a functional governance system. That work needs to be continued.

4.4. Recommendations

4.4.1 General

1. In parallel with developing the legal framework at European level, the working group recommends that a Data Protection Impact Assessment in accordance with the GDPR would be conducted, including the assessment of risks, indicators, methodology for indicators and further requirements for data protection by design.
2. The working group also recommends that clear data controller models would be drawn up including an identification and definition of the data controller(s), their roles, use cases and data flows as well as taking into account that data protection by design needs to be implemented by the data controller.
3. The working group sees that the balance between privacy, data protection and road safety should be thoroughly further assessed.

4.4.2 Legal

1. The working group considers it necessary to clarify during the interinstitutional process the potential application to C-ITS of the proposed e-Privacy Regulation and to assess the implications thereof.
2. The working group recommends continuing the work after the view from Article 29 Working Party has been received. The working group sees that it would be important to analyse how individuals could exercise their rights in terms of data protection in the field of C-ITS and how possibilities for individuals to manage their own data could best be achieved.
3. The working group sees that it would be important to assess the situation of public authorities processing personal data, to avoid that national and regional authorities find solutions that are not harmonised at EU-level once the GDPR applies.

4. The working group is also of the view that work should continue to analyse whether the technical obstacles to the use of consent as a legal basis could be solved so that a sound level of data protection and privacy could be guaranteed.

4.4.3 Technical

1. The working group recommends that the sound privacy by design concept, and the accompanying mitigation measures, is incorporated in all C-ITS implementations.
2. The working group is of the opinion that further mitigation measures concerning the possibility of tracking should be taken, such as analysing how static data in CAM can be used on their own or in combination with other information to identify a single vehicle as well as analysing any appropriate type of 'do not track' functions, as well as encryption.

4.5. Annexes

Data Protection - Annex I - Processing personal data in the context of C-ITS

5. Working Group – Compliance Assessment

5.1. Introduction

C-ITS is based on vehicle-to-vehicle communication and communication between vehicle and physical and/or digital infrastructure. To ensure that this works, it is important to ensure interoperability. It is well-known from other systems that a way to ensure this is through compliance assessment.

In this context, the generic overarching term "compliance assessment" is used, since other terms such as "type approval" or "certification" might lead to pre-conclude on specific forms of compliance assessment (which might already be established in the road transport sector).

The aim of the report of the Working Group Compliance Assessment was to define a top-level approach and methodology for testing and validation. This includes evaluating and issuing recommendations on how this compliance assessment can be achieved, with a specific focus on C-ITS stations, and on the necessary legal and organisational frameworks for the setup and the operational phase of the C-ITS network.

5.2. Organisation of Work

The organisation of work was based on regular Working Group meetings (with a total of 12 meetings in Brussels from July 2016 to July 2017 in the course of the second phase of the C-ITS platform) and also on some phone conferences to deal with specific sub-topics.

All results, outputs and expert recommendations of the C-ITS Platform Working Group Compliance Assessment have been prepared and discussed by the nominated experts representing the organisations and countries listed in "*C-ITS Platform Phase II Annex I WG*

***Participant Lists",* annexed to this report. The report of the C-ITS Platform Working Group Compliance Assessment has been approved by the Working Group on 12 July 2017 and is annexed to this report.**

5.3. Recommendations and Follow-Up Actions

- Need to set up an appropriate common EU legal and technical framework defining the functional, technical and organisational provisions to implement the proposed roles and compliance assessment requirements and process, which is summarised on Figure 2: Overview of the compliance assessment process.

- Main roles in relation to C-ITS compliance assessment are governance (C-ITS Governing Body), operation (Compliance Assessment Body) and supervision (C-ITS Supervision Body). Main decision body is the C-ITS Governing Body.

- Any new C-ITS station must fulfil the compliance assessment criteria to be part of the C-ITS security trust model.

- Considering the challenging time schedule of setting up a final organisation as described by the Compliance assessment Working Group, progressive development of this organisation should allow for deployment in a relatively short timeframe (2019).

- After 2019, the proposed compliance assessment organisation should be able to also address and ensure interoperability of existing services and future C-ITS service extensions and technology deployments.

- The proposed organisation shall have the capability allowing the introduction of new services and/or new technologies in a backward compatibility manner with already deployed services.

- Need to finalise by second half of 2018 the standards and profiles necessary to support the compliance assessment process for Day 1 services.

- Need to maintain consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.

- Further work is needed to elaborate a common EU framework to cover the roles defined by all WGs (in particular compliance assessment, privacy/data protection, security).

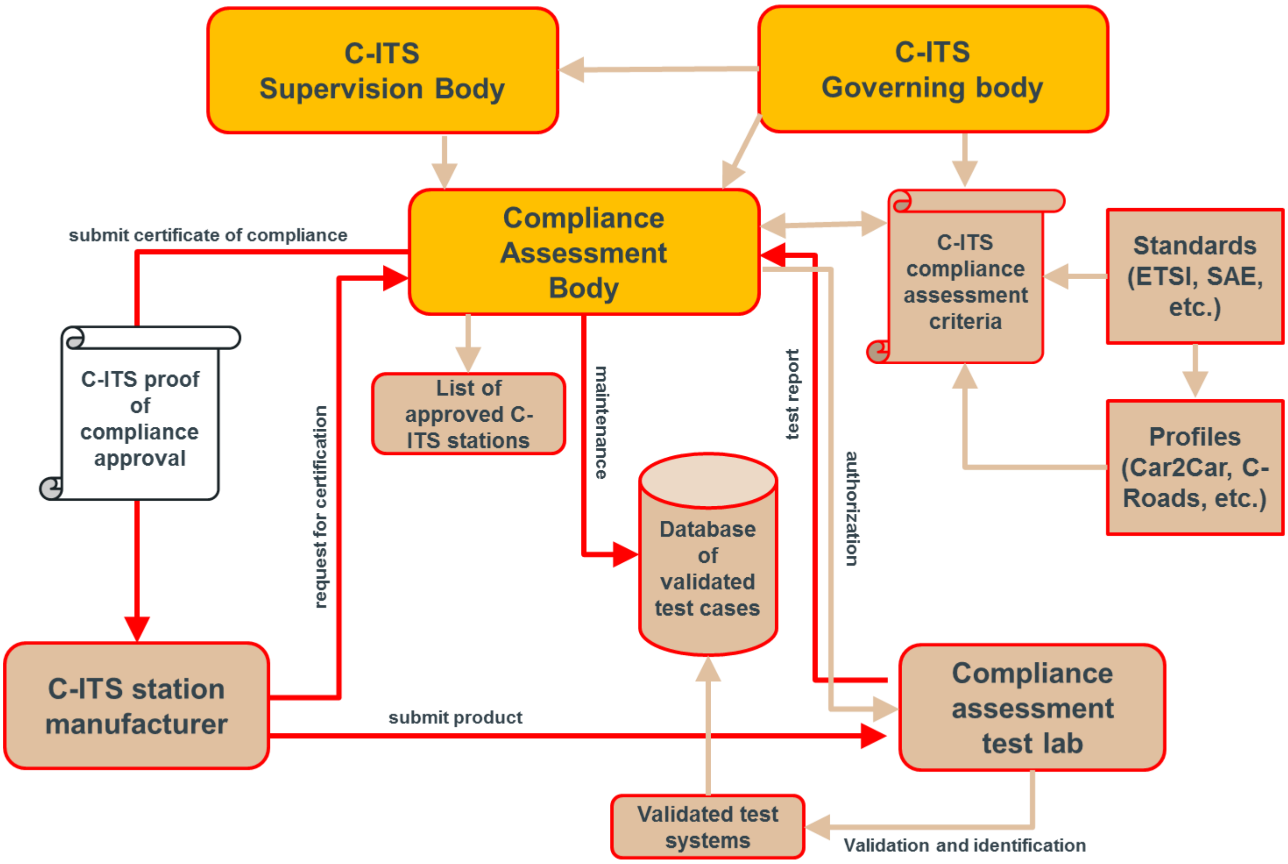

Figure 2: Overview of the compliance assessment process

5.4. Annexes

Compliance Assessment - Annex I - C-ITS platform Phase II Final Report

6. Working Group – Cooperative-ITS and Automation in Urban Areas

6.1. About This Report

Context

This report is the main deliverable of the C-ITS Platform Urban WG and represents a summary of the work conducted within the second phase of the Platform between September 2016 – September 2017.

Target Audience

A wide range of stakeholders are involved in the deployment of connected, cooperative and automated mobility in urban areas and therefore this report is relevant for all such stakeholders. Local authorities will benefit from the information about connected, cooperative and automated mobility in urban areas of this document, however national policy makers, funding authorities, standardisation organisations, C-ITS industry and research organisations are encouraged to read this document to better understand the urban C-ITS context and their role to help support its development and deployment.

The recommendations and follow-up actions developed by this Working Group are split and organised per stakeholder group.

Nature of this Report

The structure of this report is based on the methodology the WG followed and the order in which the various work items were carried out. The report itself offers a high-level summary of the discussions and the outputs.

The introduction section explains the context of urban mobility challenges and use of urban intelligent transport systems. The purpose of this section is to better understand the context of urban mobility in cities and why the various work items were undertaken and sets of recommendations were developed.

→ This section is relevant for all stakeholders

Section 6.5.1 lists the political, financial, operational and technical barriers of deploying cooperative-intelligent transport systems in urban areas identified by the WG. Urban - Annex I provides full details of this activity.

→ This section is relevant for all stakeholders, in particular policy makers and C-ITS industry.

Section 6.5.2 compares a shortlist of (day 1/1.5) C-ITS services against existing urban ITS solutions. Urban - Annex II provides full details of this activity.

→ This section is predominantly relevant for local authorities.

Section 6.5.3 lists the relevant urban C-ITS projects, available material/results, and research recommendations to support the deployment of C-ITS in cities.

→ This section is relevant for all stakeholders, in particular funding authorities, local authorities and research organisations.

Section 6.5.4 lists examples of existing and known national incentive programmes to support the deployment of C-ITS in cities.

→ This section is predominantly relevant for local authorities, national policy makers, funding authorities and C-ITS industry.

Section 6.5.5 lists the Urban C-ITS standardisation recommendations and follow-up actions.

→ This section is predominantly relevant for local authorities and European standardisation organisations.

Section 6.5.6 explores the list of day 1/1.5 C-ITS service in an urban context and identifies a set of additional C-ITS services suited for the urban environment. This activity was a key deliverable of the working group. Urban - Annex III provides full details of this activity.

→ **This section is relevant for all stakeholders, in particular local authorities, C-ITS industry and research organisations.**

Section 6.5.7 explores the roles and responsibilities of public and private stakeholders in an urban context.

→ **This section is relevant for all stakeholders, in particular local authorities and C-ITS industry.**

Section 6.5.8 explores the introduction of automation in an urban environment from the perspective of local authorities and provides a list of automation scenarios and recommendations for follow-up actions.

→ **This section is relevant for all readers, in particular local authorities, national policy makers and C-ITS industry.** Urban - Annex IV provides full details of this activity.

6.2. Introduction

Europe is home to many hundred small, medium and large cities that whilst having their own unique characteristics all share a common challenge: growing urbanisation. This leads to congested road traffic and less liveable cities. Traffic congestion is estimated to cost 80 billion euros every year and urban areas account for 23% of all CO_2 emissions from transport. [16] 25,500 people lost their lives on EU roads in 2016 and 38% of Europe's road fatalities take place in urban areas, with vulnerable users being particularly exposed. Human error is one of the great sources of accidents in transport. With high population densities and a high share of short-distance trips, there is a great potential for cities to contribute to reducing greenhouse gas emissions from transport. In fact, residents ask for reduced traffic and more free space for green spaces, recreation and social activities. In the next 30 years urban areas are expected to double in size which will lead to increased traffic demand. The challenge of managing traffic will therefore increase as space to develop road networks is limited or non-existent. In addition, travel behaviour is changing and expectations are increasing. This will put further pressure on operators to deliver innovative services.

Today the density of the road network is already very high and building new infrastructures ceases to be a viable option. The challenge for people involved in urban traffic management is how to allocate the scarce resources of road to potentially competing transport modes, within a network that has finite capacity. Furthermore, in times of scarce financial resources, any new investment constitutes a burden upon tight public budgets. For that reason, local

[16] European Commission Urban Mobility Package 2013

authorities develop urban transport and mobility policies that can achieve the best return on investment, and ensure consistency and continuity with other local and regional solutions.

The goal of local authorities for urban transport, in this respect, is to develop integrated and multimodal mobility solutions that supports and promotes the use of public transport and other sustainable modes of transport, (such as collective modes, walking and cycling) and reduces the number of fatalities and incidents. A more accessible and user friendly public transport system[17] combined with tailored on demand mobility services is a key element in urban traffic management. There is no universal solution for urban traffic management and a range of applications have been developed over many years. Static / dynamic traffic signals, parking control systems and schemes, pedestrian zones, public transport services provision, freight transport services provision and access control are some of the typical management measures found in our towns and cities. How the road network is managed can vary greatly from area to area and there are local, national and international legislation and policies that influence this. Managing traffic in urban areas is a complex, multi-layered and multi-faceted process, generally involving a range of diverse agencies. Whilst cities vary in their operational structure, a common theme is the close relationship between the local authority and the public transport operators' of a given city. National and international standards do apply to some of the management tools used for traffic management, for example traffic signals operate in a broadly similar fashion across Europe although there are some differences between Member States. However, it is local policy that is responsible for traffic management and it is likely to have the greatest influence on how urban traffic is managed. Effective Intelligent Transport Systems (ITS) enabled traffic management needs to fully take into account the needs and expectations of all local stakeholders including residents, businesses and visitors. The individual combination of services needs to function as additional traffic management tools for implementing local traffic policies. Effective traffic management enabled by ITS is a powerful tool to create modal shift that most growing cities now depend on.

Intelligent Transport Systems (ITS) have enabled operators of urban transport networks across Europe for many years to manage traffic, meet local policy goals and help meet ever-growing needs and requirements. ITS can only be deployed to their optimal effect, when they are applied within a strategic framework, following careful planning, aligned with transparent policy goals and with clear roles distributed among all relevant stakeholders. For this reason, an integrated approach towards a modal shift including different transport modes and mobility services, and bringing together both technical and policy and political considerations is essential.

[17] This includes all public transport modes, buses, trams, metro, Public Bike Share, etc.

For many decades, ITS have been deployed across Europe but its deployment has often been slow and fragmented and individually implemented. The transition between the 'innovator and early adopter' phase and the broader 'majority' take up phase of ITS deployment is often the hardest and most complex.

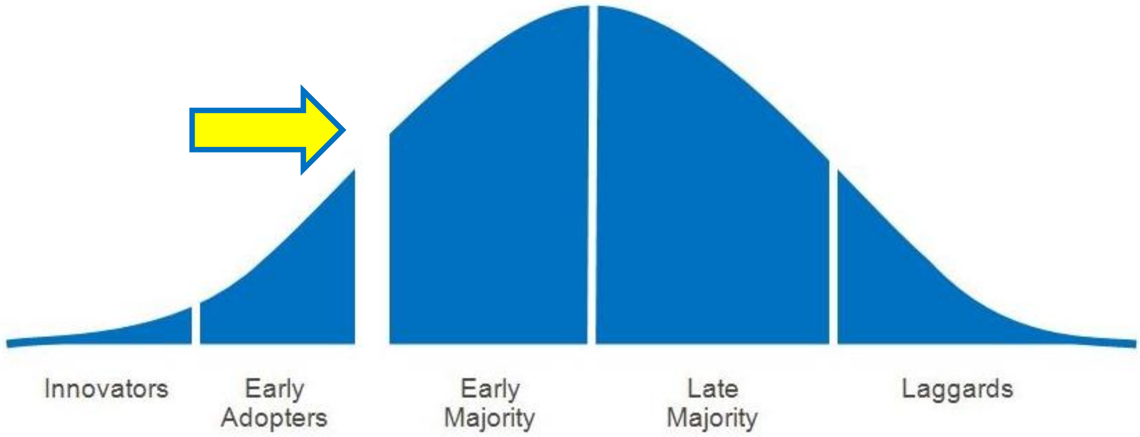

Figure 3: From innovators to Laggards

Increasingly, the roles of stakeholders along the service chain are evolving through digitalisation – there are no longer single roles but roles increasingly overlap. This brings about a radical shift in how traffic is structured, organised and operated. Anticipating and adapting to such changes will be crucially important in the context of connected and automated mobility and also mobility as a service.

A transport system can be defined as the set of actors and elements and their reciprocal interactions that determine the demand for mobility of people and goods between different points of the territory and the provision of transport services to meet this demand. A transport system can be considered smart if it is capable of dealing with safety, traffic, congestion and environmental issues and providing solutions, such as prioritizing public transport and active modes, by linking all sources of data to produce valuable information for transport users and operators. Data is an integral and essential new 'fuel' for Europe's transport sector. Together with the physical network capacity, data and information can have a positive influence on the performance of the whole transport system. Exchanging data between different actors in the transport system means supply and demand can be matched in real time, leading to a more efficient use of resources, be it a shared car, private bicycles, freight vehicles or public transport. Data supply and management is increasingly important for local authorities however it is a challenging task for many to carry out. Digital technologies help reduce human error, by far the greatest source of accidents in transport. They can also create a truly multimodal transport system integrating all modes of transport into one mobility service, allowing people and freight to travel smoothly from door to door.

C-ITS as the next generation of ITS, has the potential to play a significant role in helping cities address the problems associated with growing urbanisation. C-ITS in an urban context is all about managing traffic in a smarter and safer way in order to fulfil policy objectives. Such objectives primarily concern addressing problems created by increased traffic, pollution, emissions and making cities liveable.

C-ITS will allow connected vehicles to directly interact with each other and, for relevant services, with the road infrastructure. This interaction will allow road users and traffic managers to share and use information previously not available and to coordinate their actions. This cooperative element enabled by digital connectivity is expected to significantly improve road safety and traffic efficiency, by helping the people take the right decisions at the right time and adapt to the traffic situation, following in accordance with the actual determined local mobility management scheme/policy in place. For the traveller this could mean receiving various sources of travel information even prior to boarding any vehicle and also during the journey whether being the passenger or the driver of a public transport bus/tram/freight delivery vehicle/pedestrians etc.

C-ITS can support all (road based) transport modes, not just passenger cars as commonly perceived in the urban ITS domain. C-ITS in an urban context therefore means public transport vehicles (bus, tram etc.), vulnerable road users (bicycles, pedestrians), delivery and freight vehicles, emergency vehicles, taxi fleets, car-sharing/ride-sharing vehicles along with passenger cars. This wide range of vehicle types must be able to communicate with each other and the infrastructure and traffic management authorities. Only in this integrated and multimodal context can it be expected that local authorities will be interested in cooperative-intelligent transport systems to support strong policy objectives that aim to reduce congestion, encourage modal shift to sustainable/collective modes and enable innovative mobility services to reduce car ownership. However, like all innovative products and services, the user acceptance and benefit to the traveller must be clear and justified. The deployment of C-ITS in an urban context must benefit all types of travellers directly and it must be demonstrated that they will use the technology provided.

The objective of C-ITS is to make traffic safer and more efficient but in an urban context it is a piece of a broader puzzle of building an integrated and sustainable urban mobility ecosystem. However, as the deployment of existing ITS solutions in cities across Europe has already demonstrated, a number of challenges can be expected along with important considerations to be taken into account. This task is even more complicated when taking into account many cities across Europe still do not having 'traditional' ITS. The topic of C-ITS in urban areas has received increased attention in recent years and a number of dedicated urban C-ITS initiatives have been conducted. To bring the topic further in the spotlight amongst all C-ITS stakeholders, and learning from previous experiences with urban ITS, the basic question "are cities ready for C-ITS or "is C-ITS ready for cities" needs to be addressed.

During the first phase of the C-ITS Platform it was discussed that communication between vehicles, infrastructure and other road users is crucial to increase the safety of future automated vehicles and their full integration in the overall transport system. Cooperation, connectivity, and automation are not complementary trends; they reinforce each other and will over time completely merge. Nevertheless, higher levels of automation itself will have a profound impact on urban mobility, which needs to be addressed to figure out how it can positively enable sustainable and integrated urban mobility and not negatively influence urban mobility. In particular, the focus and emphasis of urban stakeholders on higher levels of automation is less on the technology itself and more on the **services** it can offer and shape urban mobility. In an urban context, automation services that support shared mobility are of particular interest and will likely differ from those in an inter-urban context and motorway context.

However, while C-ITS hold promise to make traffic networks safer and more efficient, the deployment of C-ITS in cities will incur costs in terms of infrastructure, data creation and processing, employment etc. Therefore, all stakeholders need to better understand what benefits they will bring, how they will support the delivery of a sustainable and integrated transport system and how these systems will work in a multimodal urban context to justify such investments.

6.3. Objectives of the Working Group

Building on the work achieved in the Implementation Issues WG of the first phase of the C-ITS Platform, the overall objective of the Urban WG was to better understand how C-ITS can be used in a multimodal urban context, in particular how it impacts and relates to public transport, what the deployment barriers and solutions are and what needs to be done at national and European levels to support its timely deployment in cities across Europe. The objective was to conduct a number of activities that **complement** existing Urban C-ITS initiatives after performing a gap-analysis. The work was conducted in a manner that respected that no one size fits all concerning the unique approach of each and every city but where relevant the commonalities between them were highlighted and addressed. The primary focus of the WG was the deployment of cooperative-ITS in cities but the link with automation was also explored. The link with automation will be a long-term activity.

6.4. Organisation of Work

The Urban WG held seven meetings between September 2016 - 2017. The work was based on face-to-face meetings and teleconferences. DG MOVE as the chair of the WG took care of organising WG meetings and teleconferences, maintaining relations with other C-ITS Platform WGs. The Urban WG worked very closely with the Enhanced Traffic Management WG.

All results, outputs and expert recommendations of the C-ITS Platform Working Group Urban have been prepared and discussed by the nominated experts representing the

organisations and countries listed in "C-ITS Platform Phase II Annex I WG Participant Lists", annexed to this report.

6.5. Work Items of the Working Group

6.5.1 Urban C-ITS Deployment Barriers

Across Europe, Intelligent Transport Systems have played a crucial role in the development and modernisation of transport systems over the last thirty years in urban areas. Within this timeframe, local authorities have invested and deployed various ITS applications to support their own local policy objectives and requirements. However, within this timeframe the deployment of ITS in urban areas has often been fragmented as highlighted above. Since 2000, cities across Europe have made bold advancements in urban ITS but a number of underlying barriers may hamper the timely and effective deployment of C-ITS in cities.

6.5.1.1 Part 1: Underlying Barriers

Political context

Local authorities have a strong political context which heavily influences what ITS is deployed, how it is deployed and when. The political landscape means that long-term planning is often constrained by frequent elections and the political priorities of the governing administration. Transport often competes with education and health care from the same scarce budget and thus investment projects need to demonstrate immediate benefits and strong added value. In particular, such investments need to directly show how the citizen will benefit and sometimes it is difficult to quantify the benefits of ITS applications and services.

Complex stakeholder structure

Urban transport by its very nature is multimodal and made up by a range of transport modes, operators and authorities. In most cases, cities have an integrated transport system, but many still have a multitude of different operators usually under the control of one authority. This means that deploying (cooperative) ITS can be more complicated and time-consuming. Competences and responsibilities concerning the introduction or deployment of new technologies are distributed over various public and private stakeholders; for example, between the road authority and public transport operator(s). In some cases, urban and inter-urban road networks are managed by different authorities with different priorities. Consequently, the structure of the transport ecosystem is complex and sometimes fragmented.

Financial

Urban stakeholders, in particular local authorities and public transport operators, are increasingly constrained by lack of funds to support the initial implementation, maintenance and continued operation of ITS systems. Depending on the business model, there may be financial implications for the local authority and other urban stakeholders. A city will invest in what it can afford. However, in the current economic climate, local budgets continue to be squeezed meaning less money is available to improve its transport system.

Market penetration rates and investments

The classic ´chicken and egg´ problem is highly relevant for ITS with stakeholders, normally only willing to invest in the relevant infrastructure once a substantial market penetration rate has been achieved unless compensation for infrastructural investments and operating costs are provided.

Timely and complicated tendering/procurement processes

Tendering and procurement is often governed by strict and detailed procedures and normally operates in cycles of 5-10 years which means procuring ITS with fast moving technologies is often a headache for many local authorities. At present, there are no harmonised processes or tools that can be used under multiple national legal frameworks.

Keeping up with the pace of innovation

Local authorities are normally risk averse to new technologies with the exception of some cities that wish to be pioneers of innovation. With high levels of public scrutiny regarding investments and public expenditure, ITS deployments must be full proof and guarantee safety and high levels of service. In addition, ITS moves at a fast pace while public processes do not normally keep up. On average, local authorities have a limited number of personnel working on traffic management and a number of tasks and projects are outsourced. The lack of resources may often severely hamper local authorities' ability to keep up with the pace of innovation and in many cases traffic management is outsourced.

Vendor and technology lock-in

ITS systems and traffic management software are often proprietary, meaning that local authorities are increasingly 'locked-in' with proprietary systems making them dependent on long-serving vendors for products and services. They are therefore increasingly unable to use other vendors or choose other technology solutions from existing legacy systems without substantial switching costs which remove flexibility to implement different types of ITS systems which C-ITS has an opportunity to address.

6.5.1.2 Part 2: C-ITS Specific Barriers

The WG conducted an exercise to identify the barriers of deploying C-ITS in cities. This highlighted that in addition to existing barriers associated with traditional ITS systems, a number of additional barriers might make the deployment of C-ITS even more difficult and complex. The exercise was conducted for a subset of C-ITS services the WG members agreed to focus on in a first step as they are broadly more relevant for urban mobility. The full details of the exercise can be found in Urban - Annex I. Across the different C-ITS services, a number of crosscutting barriers were identified:

- Lack of knowledge about C-ITS, difference between 'traditional' ITS and how to use it amongst local authorities
- Lack of awareness of full potential/benefits across entire urban stakeholder chain
- Lack of clear business models for urban applications
- Lack of knowledge about the evolving roles and responsibilities of different stakeholders
- C-ITS integration with existing legacy systems
- High investment and running costs

The following sections summarise the findings of the work items which were conducted following the initial gap analysis.

6.5.2 ITS vs C-ITS

One of the first key conclusions of the Urban WG was that in order to succeed, C-ITS needs to clearly demonstrate what it can offer on top of existing ITS systems and services. Many of the **functions** that C-ITS services offer are already available via different methods, e.g. time to green indicated by roadside countdown signs. Therefore, in relation to the list of C-ITS services being made available local authorities need to understand **why** they should update their existing ITS systems and in a subsequent step **how** they can migrate to the new systems.

For each of the C-ITS services deemed the most relevant for local authorities, an exercise was conducted to compare the functions offered by C-ITS services with examples of existing ITS systems and applications. This exercise found in Urban - Annex II enabled the Working Group to better understand the differences and gaps that may need addressing.

Function	Existing ITS Examples
Traffic signal priority request by designated vehicles	**Vienna** - a request for individual (on demand) priority can be triggered in several ways: - Infrared cameras detect the dedicated (emergency) vehicle; - electrical contacts installed on the catenary forward the impulse; - priority requests by radio communication - Electrical impulse triggered by a moving switch (after direction request by tram; also in combination with e.g. electrical contacts installed on the catenary). The data is processed decentrally, directly at the intersection.
Green Light Optimized Speed	**Hungary** - time to green/red signals in large signalled crossings using countdown timer

Function	Existing ITS Examples
Advisory GLOSA/Time To Green (TTG)	
Traffic information and smart routing	**Helmond** - camera and loop detection of congestion (due to closing times of railway crossing) at main southern access road.
Park and Ride information	**Vienna -** real time information on the number of available parking spaces at specific P&R facilities can be displayed (analog or via an application).
Road works warning	**Budapest** - Information on ongoing road works is available via online webpage, integrated with Waze navigation system information (http://kozut.bkkinfo.hu/)
Vulnerable road user protection (pedestrians, cyclists, motorcyclists)	**Helmond** - radar/camera systems to detect pedestrians and cyclists in order to increase green time at crossings. Sound support of traffic controller for visually impaired persons.
Signal violation/intersection safety	**Madrid** - has installed red light traffic safety systems that detect the steps of vehicles that pass the crossing in the red phase of the traffic light. The location information for these systems is published in the open data portal. The photographs of the infringing vehicles are received in the Traffic Management Centre of the City of Madrid and after their validation by the agents of the authority, they are processed automatically. **Budapest** - Cameras in busy intersections monitoring signal violation (red running) and prohibited turns - Cameras monitoring busy bus lanes - Extra red light for speeding cars detected before dangerous intersections with pedestrian crossings
On street parking information and management	**Helmond** - smart camera pilot at one location in Helmond to detect on street free parking spaces. Both for city management information as well as route guidance/information for individual car users.

The activity highlighted the technical differences between the different methods in terms of how the information and advice is communicated to travellers and between different actors. The need to have commonly agreed C-ITS service definitions which highlight the equivalent ITS tools that already exist and can be used was also highlighted in this task. Linked with the task on research needs, the activity highlighted the need to further demonstrate in **quantifiable measurements,** the **benefit** of performing such functions via C-ITS in comparison to other commonly used methods.

6.5.3 Research Needs

Research is often the foundation for innovation and technological advancement - planting the seeds from which new industries and markets can grow. In the field of cooperative-ITS, a substantial amount of research and development has already taken place at national, European and global level. This is crucially important for its market development and swift introduction. Increasingly, the results and findings of such research activities are needed by stakeholders to better understand the benefits of C-ITS, it's overall socio-economic impact, and increasingly, what the relationship and roles of public and private stakeholders will be to operate and manage such systems and services. Furthermore, testing and piloting is also essential to address potential weaknesses and maximise the system's performance and efficiency. However, for what concerns the testing and demonstration of C-ITS systems and services in cities, the research undertaken has been limited so far and this needs to be addressed because gaps in research activities result in development and deployment gaps at different levels later on. In particular, research of C-ITS within complex urban networks and in conjunction with a broad range of different type of vehicles incl. passenger and freight, and traffic management centres is lacking. The list of projects below summarises those identified by the WG that provide the best up to date information and useful urban specific results for local authorities.[18]

EU Project	Useful Urban Project Results	Status
CIMEC http://cimec-project.eu	C-ITS use cases, standardisation gaps and requirements, deployment roadmap	Completed
Compass4D www.compass4d.eu	Pilot results of Energy Efficient Intersection Service, Road Hazard Warning, and Red Light Violation Warning in different tests sites based on ITS-G5 and 3G/LTE.	Completed [19]
DRIVE C2X www.drive-c2x.eu	Impacts of several C-ITS services on driver behaviour, traffic safety, efficiency, environment and user acceptance based on field studies in urban environment in several European cities.	Completed
FOTNET http://fot-net.eu/	Data management and data sharing in field operational tests.	Completed
FREILOT http://www.ecomove-project.eu/links/freilot/	Project aiming at energy efficiency in urban areas. Showed clear savings fuel and CO2 by combination of GLOSA and priority for dedicated vehicles	Completed
OPTICITIES http://www.opticities.com/	A contractual framework on data access and exchange policy allowing enlarged access to high quality data	Completed
TEAM http://www.collaborative-team.eu/	TEAM Tomorrow's Elastic Adaptive Mobility developing collaborative ITS for city environment	Completed
VRUITS www.vruits.eu	ITS VRU Implementation Scenarios and ITS Assessment, VRU Integration Architecture and	Completed

[18] This list is non-exhaustive; in particular, national level projects that the WG were not aware of are not listed here.

[19] Project partners are continuing the C-ITS services beyond the original project timeline

EU Project	Useful Urban Project Results	Status
	Recommendations, Exploitation Plan	
AUTOCITS www.autocits.eu	Pilot testing of C-ITS services for automated vehicles on outer-ring roads entering cities in Paris, Madrid, Lisbon	On-going
CAPITAL http://capital-project.its-elearning.eu	Preparation of C-ITS training and educational resources for local authorities	On-going
C-MOBILE http://c-mobile-project.eu/	Large-scale deployment of bundled C-ITS services in complex urban and extra-urban areas in 8 cities across 6 MS. incl. interactions with VRUs. On a small scale the extension towards automated driving is piloted.	On-going
CODECS www.codecs-project.eu	Common technical specifications for interfacing the vehicle and urban traffic management system & urban transport authority C-ITS requirements	On-going
CO-GISTICS http://cogistics.eu	Pilot results of C-ITS for logistics - Intelligent Truck Parking and Delivery Areas Management, Cargo Transport Optimisation, CO2 Footprint Monitoring and Estimation, Priority and Speed Advice and Eco-Drive Support.	On-going
C-ROADS https://www.c-roads.eu/	Pilot testing of C-ITS services (CZ, FR in particular useful for inner-city testing)	On-going
C-THE-DIFFERENCE www.c-thedifference.eu	Pilot testing of different C-ITS services in Helmond and Bordeaux based on ITS-G5 and 3G/LTE.[20]	On-going
SPICE http://spice-project.eu	Preparation of ITS Procurement Guidelines	On-going

Based on the gap analysis of available research of Urban C-ITS, a set of research recommendations based on city requirements have been developed. Underlying advancements on security and privacy is a pre-requisite for all of the points listed below:

1. Urban research at European and national levels over the next 5 years should include a large focus **on cooperative-ITS in a complex urban multimodal environment**. The role of automation is crucially important to research but in the short-term research projects and initiatives should continue to focus on further analysing, developing and testing C-ITS systems in a complex urban environment.

2. Pilot and demonstration projects have so far focused on evaluating the benefits of new systems and technologies without comparing them to existing versions. **Conducting research that compares existing ITS systems with upgraded or new C-ITS systems**[21] is

[20] The C-ITS services that will be tested in this project closely mirror the same C-ITS services analysed in more detail by the Urban WG in various tasks.
[21] Conducting such research is feasible provided that the baseline data is available.

desirable. Such finding and research would be highly advantageous for urban stakeholders to better understand the differences and advantages/disadvantages of C-ITS with existing ITS systems in relation to their specific needs.[22] Projects and initiatives must also ensure that results, whether negative or positive, are conveyed in a neutral and unbiased manner. Such results must quantify the results in a way that are easily understood and useful for local authorities and demonstrate how they can support local policy objectives i.e. congestion, pollution, modal shift etc.

3. Future research should include a **broader and more specific range of Urban C-ITS services** beyond those listed in the Phase I day 1 / day 1.5 lists but also the additional urban services defined by the Urban WG in section 6.5.6 of this report incl. Annex III[23] and other relevant projects such as CIMEC.[24]

4. Projects and pilots in the future will need to include a **larger amount of vehicles** and a **wider range of vehicles types, including public transport (bus, tram), emergency vehicles, freight and vulnerable road users (pedestrians, cyclists, motorcyclists, etc.).** Current research has predominantly been tested on private passenger cars. In addition, the network coverage of future projects should also focus more **multimodal intersections** within cities. The of integration between C-ITS and the **traffic management centre** should also be better explored. The focus of such projects should not just be on passenger mobility but also urban freight (incl. city hubs and ports) and the link between them.

5. **Enhanced and harmonised evaluation methodologies** that can cater for high levels of data and include more **safety** and economic related KPIs are important. More emphasis on analysing and evaluating user behaviour (i.e. making relevant decisions after receiving information or ignoring C-ITS messages) and liability considerations for public authorities is desirable and essential incl. developing a **common evaluation methodology including common KPIs**, so that results from various pilot tests and deployments can be compared.

6. **International activities** such as twinning partnerships and knowledge sharing on deployment and upscaling paths are strongly encouraged to aid the exchange of best practice and would help follower cities to define their own customised strategy and associated planning for successful implementation

In this context, the urban nodes of the European TEN-T network may be highly suitable to address the research needs and recommendations.

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[22] Moreover, such analysis can also evaluate the impact of bundling multiple C-ITS services together.
[23] The CIMEC project also defined a large and more detailed list of urban uses cases and the C-MOBILE project will test bundles of approximately twenty urban related C-ITS services.
[24] http://cimec-project.eu/

6.5.4 European and National Incentive Programmes

As identified during the deployment barrier analysis, local authorities may require financial and technical support to invest in C-ITS systems. In the current financial climate, local authorities across Europe are struggling financially to enhance and develop their transport system. Investing in C-ITS for local authorities may require investing in the relevant digital infrastructure and without financial and technical support, the stage in which cities invest in C-ITS may be severely delayed. To better understand the context of what help is currently on offer to help local authorities at European and national levels, the following analysis was conducted by the WG in conjunction with the EU ITS Committee. Below is a set of examples of Member States[25] which offer financial and technical support for local authorities to invest in C-ITS, either through existing ITS programmes or new dedicated ones.

Program	Details
Finnish National ITS Infrastructure Grants (up to 50%)	Today (2017) state supports public transport in municipalities by EUR 85 million/year. Most of this is allocated to buying transport services or getting lower prices for customer (area tickets). Cities can use this money also for developing and building costs of public transport information and ticketing systems, priorities for public transport (traffic lights) and multimodal terminals, but most of the support is used to enhancing the service level. The state can pay up to 50 % of the costs, but usually percentage is lower. Finnish Transport Agency also coordinates and funds nationwide ITS development projects for local authorities such as piloting real-time information systems and cooperative ticketing & payment systems. We have introduced in Finland also common platform with cities and other stakeholders to develop ITS systems and services. It is called a Traffic Lab. Finland are updating the whole transport legislation more suitable for ITS and digitalisation. First part of legislation has accepted in parliament and will be into force next summer. Finnish Transport Agency's (FTA) mobility management funding and e.g. 6aika funding can support C-ITS development in Finland's urban environment.
Dutch National C-ITS Infrastructure Grants (50%)	Within the Talking Traffic Partnership and Beter Benutten the Ministry of Infrastructure and the Environment, 12 regions (including 55+ cities) and three clusters of private enterprise, work on a new chain of data exchange and information services for the road user. The joint public parties (including a large amount of cities) work in a coordinated way to have around 1,250 traffic light installations (a quarter of the total number in the Netherlands) replaced, as well as a working chain of information services towards the road user, both by the end of 2017. Therefore joint working groups are set up, on both technical solutions guaranteeing interoperability and other requirements, as well as business development

[25] The Czech Republic operates a National Transport Programme including ITS in cities, France runs Public Transport and Sustainable Mobility Programme + National Innovation Funding Scheme and Estonia operates a National ITS Funding scheme all of which could be used to support C-ITS in cities

	and modernizing traffic light installation. Local authorities may apply for a grant to cover 50% of relevant infrastructure costs. The total budget of Talking Traffic is 90 mln for the period 2017-2020. The Ministry of Infrastructure and Environment and decentral authorities together invest € 55 mln. of the total budget.
UK Department for Transport C-ITS Schemes	The Department for Transport wants to promote the use of Cooperative Intelligent Transport Systems (C-ITS) on the local highway network and has provided £4 million for C-ITS and connected vehicle applications. This provided funding for 19 local authority schemes through the recent Funding For Innovation competition, including further funding for the C-ITS Corridors for Newcastle City Council.
EU ELENA Scheme[26]	ELENA is a joint initiative by the EIB and the European Commission under the Horizon 2020 programme. ELENA provides grants for technical assistance focused on the implementation of energy efficiency, distributed renewable energy and urban transport projects and programmes. The grant can be used to finance costs related to feasibility and market studies, programme structuring, business plans, energy audits and financial structuring, as well as to the preparation of tendering procedures, contractual arrangements and project implementation units.

6.5.5 Urban C-ITS Standardisation

Cooperative systems require communication and implementation processes and therefore standards are crucial to ensure interoperability, to enable migration paths from existing ITS infrastructure and to avoid technology and vendor 'lock-in'. Cooperative systems are already broadly standardised, however there are a number of gaps concerning urban C-ITS. Standardisation in the field of urban ITS is technically and organisationally complex and as the Urban ITS Standardisation Mandate highlighted[27], standards are often not fit for purpose at a local level, do not fully take into account the requirements of local authorities and can be difficult for the local authorities (incl. technicians and traffic managers) to understand and use.

As part of the CIMEC project, a dedicated activity was conducted to clarify how C-ITS will be integrated in cities' ITS architecture and to identify any standardisation issues that are currently not reflected incl. sub-systems, communication or processes.

To build on this work already completed, a dedicated meeting was held between the WG members and relevant representatives of the European Standardisation Organisations (ESOs) to discuss the findings and define a set of follow-up actions. Such support should not thwart innovation, but rather enable open and flexible implementation.

Recommendation	Follow-up/Action

[26] http://www.eib.org/products/advising/elena/index.htm
[27] https://www.urbanits.eu/publicdocuments

	Recommendation	Follow-up/Action
1	Standards already in use in Urban ITS that need to be adapted Establish a suitable platform for industry led national or regional SDOs in charge of existing urban standards & keep cities and stakeholders(preventively) informed about conclusions/activities	To be addressed ESOs (notably new CEN Urban WG 17 and with ETSI) as a starting point. European Commission to host ad-hoc meetings in addition.
2	Requirements to enable C-ITS standards in the urban environment Funding/co-funding schemes for urban standardisation and technical capacity (guidelines) development	To be potentially addressed within forthcoming ICT Rolling Plan linked with Urban ITS Mandate or relevant on-going projects.
3	Standards that have impact on urban operators' business processes Agree on the existing and relevant list of C-ITS standards and instruments to raise awareness	To be addressed with ESOs and ISOs.
4	Support for procurement and deployment Launch a dedicated activity to describe required functional requirements, technical specifications and communication profiles for C-ITS services and equipment for operators. Extend described supporting actions to build up technical/financial capacity to develop and improve test standards and field operational testing as a whole. Accelerate the development process of conformance tests for infrastructure-based messages, e.g. SPaT/MAP. Common definitions to be addressed.	To be potentially addressed within relevant on-going projects - in particular the development of an 'urban specification profile' based on common functional requirements.
5	Interface interoperability, multi-vendor integration Support the urban ITS-pre study (PT1701) recommendation of having a European-wide control interface standard to link roadside devices such as signal controllers to installation / center systems. Standards to enable migration paths from existing systems towards novel solutions.	To be addressed within the Urban ITS Standardization Mandate Projects.
6	Investigate interoperability and compatibility of public transport communication standards and C-ITS standards.	To be addressed within ESOs and ISOs.
7	Enable harmonised C-ITS service interoperability including the Management for Electronic Traffic Regulations (METR)	To be addressed within ESOs and ISOs.

6.5.6 Urban C-ITS Services

One of the first key conclusions of the Urban WG was that in order to succeed, Cooperative-ITS in an urban context needs to match local policy goals, address problems local authorities are currently facing and should be tailor-made for the urban context which is unique for a number of reasons:

- The general objective of reducing traffic, pollution and congestion to create more liveable cities
- Priorities for certain transport modes and intersections i.e. public transport, emergency vehicles, active modes etc.
- Cultural and behavioural aspects
- Geographical situation and configuration of existing road network
- Robustness of networks
- Technical and operational characteristics of the public transport network
- Multitude of road operators, particularly in inter-urban areas
- Parking availability and policy
- Multimodality/mixed traffic and safety implications of vulnerable road users (VRU)

For many decades, cities across Europe are facing ever-growing urbanisation and as a result, their transport networks are experiencing an enormous strain making congestion, pollution and safety worse. Policy objectives are increasingly focused on modal shift to public transport, walking, cycling and integrated mobility schemes in order to increase cities safety, air quality, liveability and welfare. Every city is different and no one-size fits all approach should be applied but there are some common barriers and elements between them. Any introduction of C-ITS should not lead to increased traffic in cities but it should rather facilitate further improvements in modal shift and integrated multimodal transport systems. Out of the day 1 and 1.5 C-ITS services there were a number of services that were deemed more desirable for local authorities than others i.e. those focusing on public transport use and active modes like cycling and walking etc. However, there were also a number of services, which were deemed as less desirable and less relevant in low-speed network with different transport modes. In addition, there are a number of local transport challenges and problems which C-ITS could address but were not covered by the current list (i.e. urban access control).

As a result, the WG identified a subset of relevant services from the Day 1 and Day 1.5 list that best fit within the overall context of sustainable urban mobility and multimodal/ integrated transport. This list should not be seen as the 'official urban C-ITS service list' of the C-ITS Platform. The list of C-ITS services that will be most desirable will vary from city to city depending on their local context.

Level	C-ITS Service	Score
Day 1	Traffic signal priority request by designated vehicles	14
Day 1	Green light optimized speed advisory GLOSA/time to green (TTG)	12
Day 1.5	Traffic information and smart routing	10

Day 1.5	Park and ride information	9
Day 1	Road works warning	6
Day 1	In-vehicle speed limits	6
Day 1	Probe vehicle data	6
Day 1.5	Vulnerable road user protection (VRU)	6
Below threshold (in order from 5-0)		
Signal violation/intersection safety, On street parking information and management, Weather conditions, Information on AFV stations and charging points, Traffic jam ahead warning, Other hazardous notifications, In-vehicle signage, Off street parking information, Connected & Cooperative navigation into and out of the city, Slow or station vehicle(s), Emergency electronic brake light, Emergency vehicle approaching, Shockwave damping.		

The need to agree and define harmonised **definitions** of C-ITS services, and their requirements (service or various use case descriptions) that are understandable and appropriate for all stakeholders was highlighted as an important requirement during this process. The WG did not define definitions for the aforementioned services as this task is currently being undertaken in other C-ITS initiatives, notably the C-ROADS Platform and dedicated Urban C-ITS projects including C-the-difference and C MOBILE.

The next **core activity** of the WG was to go beyond the existing list of C-ITS services and define a set of additional services specifically relevant for the urban network that, if developed and implemented, would bring a strong added value to local authorities and the urban transport network.[28]

The table below provides a high-level summary of the identified additional services. Urban - Annex III provides a list of the Urban WG Additional Urban C-ITS Services, including information on basic service descriptions (including safety critical and safety related services), explanations/justifications, basic technical and functional requirements and roles and responsibilities of different public and private stakeholders. As C-ITS develops over time it can be expected that even more urban specific services will be developed. In particular, public transport and vulnerable road user/cyclist services have a large potential to grow (e.g. connected bikes[29] and emissions management).

New Additional Urban Specific Services
Access Zone Management (restricted lanes, zones, tunnels/bridges, management of freight loading/unloading areas) **V2I**

[28] The list build on the work of other projects that have defined more urban specific C-ITS services, notably in the CIMEC project

[29] https://bycyklen.dk/en/the-bycykel/

Public Transport Vehicle Approaching V2V
Extended Functionality of Original List of Day 1/1.5 Services
Access management of speed (i.e. near identified priority zones by local authority) - subset of in-vehicle signage **V2I**
On-street and off-street parking management - subset of on-street and off-street parking information **V2I**
Temporary traffic light prioritisation for designated vehicles - subset of traffic light prioritisation of designated vehicles **V2I**
Collaborative perception of Vulnerable Road Users (VRUs) - subset of VRU road user protection **V2V**
Collaborative Traffic Management - subset of connected, cooperative navigation into and out of the city **V2I**
Additional User Groups of Existing C-ITS Day 1/1.5 Services
GLOSA for cyclists V2I

These additional services were not classified as 'Day 1/1.5/2'. The technical and functional requirements indicate that some services are easier to implement than others, however local authorities highlighted that such classification is not as relevant or meaningful than for other stakeholders. Local authorities will determine which C-ITS services to invest in once available based on their local needs and at a stage which matches their own development strategy and activities.

The objective of the aforementioned services is to inform, advise, and where relevant, ***reinforce*** local traffic regulations. The ***enforcement*** of local traffic regulations via such C-ITS services was not included within the description of the services that were elaborated however the discussions within the WG highlighted the interest of some local authorities in using C-ITS to enforce local traffic regulations. Local authorities are already making significant investments in other ITS systems to perform similar functions (i.e. camera detection systems). They are therefore increasingly looking at other means to maximise the efficiency of local traffic regulations. However, due to complications with data privacy, liability, building consensus with all actors and potential side effects with user acceptance the enforcement capability of the C-ITS services was not included in the description of any service. However, it is important to highlight that the potential use of enforcement is not unique issue in urban areas but potentially applicable for all parts of the network.

Security is paramount to the deployment of C-ITS. A common standardised C-ITS trust model and certificate policy based on Public Key Infrastructure (PKI) is currently being finalised within the Security WG of the C-ITS Platform and deployed by stakeholders. In an urban environment the security of cooperative-ITS is essential. Whilst it was agreed that there are no specific urban characteristics that need to be addressed with the security developments, it was encouraged that local authorities should have an active role in the relative C-ITS security developments. The work of the security WG can be found in section 3.

Vehicles equipped with C-ITS that use CAM and DENM messages are constantly broadcasting data, including their speed and location, raising the potential concern of how to guarantee privacy and data protection. The work of the data protection and privacy WG can be found in section 4.

The deployment of the aforementioned C-ITS services will have an important infrastructure component both in the 'physical' and 'digital' sense. Road infrastructure was traditionally seen as concrete and asphalt, road signs and traffic lights, bridges and tunnels, but today this is complemented by what is commonly referred to as 'digital infrastructure', such as digital mapping and real-time traffic information. Digital infrastructure can be seen as an accurate, dynamic and live digital representation of the physical infrastructure. This digitisation of infrastructure could greatly support connected and automated vehicles into understanding their surroundings and facilitate new possibilities in dynamic traffic management. This does raise however new topics, such as the need to maintain a high quality standard for this digital representation, both on accuracy and timeliness of the updates, requiring an increased collaboration between public and private sector, between road authorities and C-ITS service providers. In an urban context, a wide range of physical infrastructure can be found and the task of developing the digital infrastructure will be complex. The physical and digital Infrastructure WG explored this topic in detail and the main outputs and recommendations can be found in section 9.[30]

6.5.7 Roles and Responsibilities

Cooperative-ITS by its very nature will require the close collaboration and interaction between different public and private stakeholders. Increasingly, the roles of stakeholders along the service chain are evolving through digitalisation - there is no single role anymore; roles increasingly overlap rather than specific tasks for specific players which bring about a radical shift in how traffic management is going to be structured, organised and even operated. Whilst conducting the aforementioned ITS vs. C-ITS and Urban C-ITS services exercises, the WG analysis defined at a high level the different roles and responsibilities of stakeholders based on four core functions:

Vehicle Communications: it was understood by WG members that the business models of C-ITS deployment would influence which stakeholder would be responsible for the installation of the relevant on-board units across the different vehicles. For example, the public transport operator may take the responsibility as part of a business decision and also due to the fact they are in the position to request certain equipment during a tender and service

[30] These aspects are also currently being addressed by the Innovation Platform TM 2.0.

level agreements etc. but it could also be local authority directly as part of a local strategy. Moreover, it could even be part of a legal requirement.

Infrastructure installation and maintenance: it is quite clear that local authorities play a significant role concerning C-ITS infrastructure. For what concerns the use of ITS-G5 communication the local authority would normally bear the responsibility of installing and maintaining the roadside unit, but this could also be conducted by private service providers. For what concerns cellular communication the local authority would need to pay to access the relevant network.

Service operation: who will operate the relevant C ITS services is an important consideration that deserves more attention. Generally speaking, both private service providers and the local authority can operate the C-ITS service, however depending on the type of service and the associated business model, it may be more appropriate for the local authority to operate, if feasible. For example, for services that help improve the efficiency of the network (GLOSA, etc.) the service could be run by either a private service provider or the local authority. However, for what concerns C-ITS services which are used to reinforce local traffic regulations (i.e. parking management, urban access control) it may be more appropriate for the local authority to operate and less appealing for private service providers. However, this topic was not given full sufficient attention within the WG and should be addressed in further detail in the short term.

Data Supply and Management: the operation and management of cooperative-intelligent transport systems requires a substantial set of data and 'digital infrastructure' as defined in the physical and digital infrastructure WG. These data, including data related to electronic distribution of local traffic regulation, require data collection, data management and data distribution. This is a new functionality, that may be implemented in different ways, but is a new core service provision, without which C-ITS will not function effectively in the urban environment. The required data for C-ITS systems will be needed from both public and private actors and should be accessible and shared in an easy, cost-effective and non-discriminatory manner. However, which data should come from which actors and how should it be accessible and shared amongst all stakeholders. Annex II and III define the data management requirements for each of the C-ITS services listed and was explored in detail within the Enhanced Traffic Management WG. However, the availability of data (digital data that has been created) is also an important characteristic; as such data does not exist in many cities in Europe. It is recommended that both topics are explored in further detail after the second phase of the C-ITS Platform. In this regard a framework must be established in order to regulate the use and protection of data.

The WG also identified that the future business models of cooperate-intelligent transport systems may change and update traffic management in the future and should be further addressed within the relevant WG and platforms. Cooperative-ITS by its very nature will undoubtedly change and update traffic management as we know it today in its structure and operation and new business models will be required to ensure the sustainability of C-ITS services. The Enhanced Traffic Management WG explored in significant detail what the future traffic management model may look like and what roles and responsibilities of public and private actors may become. The main outputs and recommendations of the WG can be found in section 10. Appropriate business models to support the deployment of C-ITS is a crucial factor in an urban environment as identified in the deployment barrier exercise. The dedicated business model WG explored this topic in detail and the main outputs and recommendations of the WG can be found in section 7.

6.5.8 Urban Automation

Across the EU, at least 12 Member States have facilitated the testing of highly automated (including public transport) vehicles on public roads.[31] In parallel, technological developments have rapidly progressed meaning highly automated vehicles across different modes (passenger cars, mini buses etc.) are ready to be tested and piloted. Trials in some cities are already taking place (London, Paris, Strasbourg, Vienna, Trikala, Gothenburg etc.) and in some cases the testing began without the need of prior approval of the local authority. However, current traffic laws need to be changed to upscale pilots and regulate coexistence of mixed traffic. For cities across the EU, the potential arrival of high levels of automation raises the prospect of safety and liability issues (also in relation to insurance), increased traffic and consequently worsened pollution and congestion if not tailored and shaped towards the needs of local authorities. While some studies have demonstrated that automated transport can in theory positively impact traffic and congestion levels in cities (OCED ITF, 2015[32]) through shared use etc. other studies have equally highlighted that theoretically traffic and congestion could actually **increase** with automation under certain scenarios discouraging modal shift (BCG Amsterdam and Danish Road Directorate 2015[33], Wadud et al 2016[34]).

It has been projected over the years that automated highways will be the main use case of automated driving. However, in recent years the prospect of automated driving in cities has gained a lot of attention with many realizing that despite the tough technical challenge of operating in cities, especially in mixed traffic, it has a far bigger potential commercial prize.[35] In particular, the user acceptance of higher levels of automation may favour the low speed urban environment in the first instance, as passengers will feel more safe driving at lower speeds in a city than driving at higher speeds along a motorway. The urban application of

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[31] Input gathered from informal ITS Committee consultation

[32] https://www.itf-oecd.org/sites/default/files/docs/15cpb_self-drivingcars.pdf

[33] Traffic increases 15%

[34] Zia Wadud, Don MacKenzie, Paul Leiby, Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles, Transportation Research Part A: Policy and Practice, Volume 86, 2016, Pages 1-18, ISSN 0965-8564, http://dx.doi.org/10.1016/j.tra.2015.12.001.

[35] https://www.bbhub.io/dotorg/sites/2/2017/05/TamingtheAutonomousVehicleSpreadsPDFreleaseMay3rev2.pdf

higher levels of automation may also have a significant social and employment impact with many drivers employed by public transport operators, taxi firms, freight and logistic companies etc.

Before highly automated vehicles are commercially available and while the legal framework is not yet finalised, this current period represents a **window of opportunity** for local authorities to plan how highly automated vehicles will be managed and operated in a urban environment, otherwise they face the prospect of the technology arriving when they are not ready and prepared. However, the technology itself is not the prime concern of local authorities but actually the **mobility services** themselves that they can offer.

Local authorities have a range of possibilities in shaping how automated vehicles can operate in their city. However a key question for local authorities is WHEN they should start such planning. Moreover, it is important to define if such planning only concern higher levels of automation or also level 2 / 3, which could also be problematic.

To properly and effectively prepare, local authorities need a clear and realistic timeframe of when automation will arrive and precisely which technical infrastructure is possibly the best investment. The discussions within the WG highlighted the various positions of different stakeholders ranging from 5 to 50 years. In such a scenario it is impossible for local authorities to effectively and confidently conduct such planning if it is not yet commonly known and agreed when such technology will be deployed. Therefore, forums of discussion between vehicle manufactures, Member States and local authorities facilitated by the European Commission are essential to continue the discussion.

However, at this point in time it was agreed that it is important for local authorities that the following aspects are explored/further investigated:

6.5.8.1 Demonstrate to industry stakeholders how automation should be used to support integrated and sustainable urban mobility and which scenarios must be avoided

It is clear that simply replacing existing cars with automated cars will not necessarily further enhance integrated and sustainable mobility, in fact it may have the opposite effect if not coordinated properly:

- Congestion rates may stagnate or even increase;
- there may be a modal shift away from cycling, walking and public transport as the attractiveness of cars increases;
- the infrastructure normally allocated for public transport and other /sustainable modes (e.g. bikes and taxis) and/or parking spaces could be even be removed to provide fixed lanes for automated vehicles;

- parking could be avoided by automated vehicles further increasing traffic

The promotion and support of automated vehicles by public authorities should be based on solving social problems in urban areas for all citizens. What is also clear is that if implemented and coordinated correctly, automation could potentially enhance and complement existing urban mobility. The WG defined a set of different scenarios in Annex IV where automation could have a positive impact on urban mobility, including public transport. Every city is unique and no-one size fits all, but the different scenarios represent examples that show how automation could be beneficial for cities. The scenarios identified would need rigorous testing and demonstration at national and European levels and include the involvement of local authorities. A summary is presented below and the full details of the exercise can be found in Urban - Annex IV. Operation would vary from city to city and operator to operator (zone of operation, fixed stations, segregated infrastructure or mixed traffic, etc.). Optimal scenario includes link with electric vehicles/other alternative fuels.

Scenario[36]	Description
1. (Fully) automated car-sharing /car-pooling services within a city	Existing car-sharing and car-pooling services but fully automated.
2. (Fully) automated taxi services	Existing taxi services but fully automated.
3. (Fully) automated shared mobility services for fixed routes in designated zones	Shared automated vehicles could provide transport services for fixed routes in designated zones of a city i.e. shopping districts/main financial hubs.
4. (Fully) automated shared mobility services for rural areas	Shared automated vehicles could provide transport services within rural areas and connect with the suburban network.
5. (Fully) automated shared ´feeder´ services to connect with local public transport network	Shared automated vehicles could provide transport services that connect directly to the local public transport network (i.e. first/last mile in less populated areas-suburbs).
6. (Fully) automated public transport systems	Automated public transport systems (12-18m buses, light rail systems) could be provided in the urban transport system.
7. (Fully) automated freight deliveries	Automated vehicles could provide local freight-delivery services i.e. small automated delivery trucks or pods for supermarket´s home delivery service, parcel systems etc.

[36] Within all scenarios, the use of alternatively fuelled vehicles is desirable to reduce emissions and air pollution

6.5.8.2 Identifying which tools and enablers can be used by urban stakeholders to influence the operation of automated vehicles and what they need to prepare for in advance

Urban stakeholders have a number of tools at their disposal to influence how automated vehicles can operate in a city. Every city is unique and no-one size fits all however there are a number of common functions and responsibilities available which can aid local authorities when panning for the introduction of automated vehicles. Such tools include adapting local traffic regulations and developing dedicated AV infrastructure restricting where automated vehicles can drive, encouraging car-pooling/car-sharing already today, facilitate links to highly efficient collective transport (such as metro lines), and introducing road pricing etc. Sustainable Urban Mobility Plans[37] and Sustainable Urban Logistics Plans[38] can be an effective tool for local authorities to integrate such planning within the broad strategy of integrated and sustainable urban mobility.

6.5.8.3 Complementarity of C-ITS and automation

Communication between vehicles, infrastructure and other road users is also crucial to increase the safety of future automated vehicles and their full integration in the overall transport system. Cooperation, connectivity, and automation are complementary and not alternative trends; they reinforce each other and will over time completely merge. If local authorities make investments in C-ITS systems, they want a return on their investments rather than something which become obsolete in the future. To achieve high levels of automation in urban mobility, C-ITS will have a key role. However, further research in the long term is needed on how C-ITS can enable the safe and efficient use of automation in cities.

6.5.8.4 Safety

A key deployment barrier of automated vehicles is the boundary condition that they are safe enough to drive on public roads. Partial automation, intended to take over some of the driving tasks, is in principle intended to make driving and traffic not only more comfortable but also safer. However, the deployment of such partial automation functions raises some new safety challenges. Connected and automated vehicles, and solutions based on C-ITS need to demonstrate a safety enhancing performance. The safe deployment of connected and automated vehicles requires that the technical regulations which define the performance of partially or fully automated vehicles are conceived, defined and tested taking into account the interaction of these vehicles with the human driver and other road users.

[37] https://ec.europa.eu/transport/themes/urban/urban_mobility/urban_mobility_actions/sump_en
[38] http://novelog.eu/

All road users involved in traffic: including fully or partially automated motor vehicles, non-automated motor vehicles, motorcyclists (non-automated yet), cyclists and pedestrians must respect the rules of behaviour established in each Member State's road traffic laws and cross-border Highway Code recognition and enforcement. These rules may need to be updated to reflect a traffic environment including connected and automated vehicles, which in turn will need to integrate some, or eventually all, of these rules of behaviour into the system design (coded into the system software). The Road Safety WG of the C-ITS Platform investigated this topic in detail and the main output and recommendations can be found in section 8.

6.5.8.5 EU Funded Projects: Automation in Urban Ares

Project	Useful Urban Project Results	Status
AUTOPILOT http://autopilot-project.eu/	Enhance the driving environment perception with IoT sensors enabling safer highly automated driving; Foster innovation in automotive, IoT and mobility services; Use and evaluate advanced vehicle-to-everything (V2X) connectivity technologies, Involve Users, Public Services, Business Players to assess the IoT socio-economic benefits; Contribute to the IoT Standardisation and eco-system.	On-going
CO-EXIST https://www.h2020-coexist.eu/	Analysis on the effects of automated vehicles on urban road infrastructure and the co-existence between automated and conventional vehicles in mixed traffic.	On-going
CARTRE https://connectedautomateddriving.eu/about-us/cartre/	Its objectives include the creation of a knowledgebase of all European activities; to setup a platform for sharing and re-using data and experiences from different automated road transport systems; to actively support Field Operational Tests (FOTs) and pilots carried out at National and European levels; and to work on future visions, potential impacts and research gaps in the deployment of automated road transport.	On-going
HEIGHTS http://hights.eu	Pilot testing of location precision, robustness and latency - automated driving, platooning and safety of vulnerable road users.	On-going
MAVEN http://connectedautomateddriving.eu/project/maven	Infrastructure assisted algorithms for the management of automated vehicles, which connect and extend vehicle systems for trajectory and maneuver planning.	On-going

In the near future, a number of H2020 projects on urban automation will be conducted under the following calls:

- H2020 Smart Green and Integrated Transport - Call 2017: **Topic ART-07-2017** 'Full scale demonstration of urban road transport automation'. (CLOSED)

- H2020 Smart Green and Integrated Transport - Call 2019: **Topic DT-ART-03-2019** 'Developing and testing shared, connected and cooperative automated vehicle fleets in urban areas for the mobility for all'. (TO BE LAUNCHED)[39]

The ERTRAC Technology Platform also published an 'Automated Driving Roadmap'[40] in June 2017 which provides common definitions of automation levels and automated driving systems, agreed within the industry and public authorities. It presents development paths for automation of road transport for three applications: passenger cars, freight vehicles, and urban mobility vehicles (which include both Personal Rapid Transit (PRT) including Urban Shuttles and City-buses and coaches). It projects that highly automated vehicles are planned around the year 2030 in urban areas. The Roadmap set up 11 challenges to be tackled for automation to become a reality in Europe. It calls for collaborative Research & Development activities at European level, in order to ensure harmonization and inter-operability. It is also a reference document listing all European projects and activities supporting connected and automated driving, as well as the initiatives taken at national level by EU Member States.

6.6. Recommendations and Follow-Up Actions

For the European Commission
➢ **Ensure that during the development of the forthcoming C-ITS Delegated Act under the ITS Directive Urban C-ITS stakeholders shall be consulted, in particular for urban related matters;** ➢ **In view of further research and pre-deployment of C-ITS activities in Europe the available funding instruments (e.g. CEF, H2020, EIB, Regional Funds) should take into account the research recommendations defined in section 6.5.3;** ➢ **Provide dedicated financial and technical support for local authorities and public transport operators to invest in C-ITS related to local urban transport and mobility schemes influencing the modal split towards more sustainable urban traffic policies and modes;** ➢ **Facilitate the exchange of best practise between local authorities by continuing to host a centralised forum of discussion and a digital library of relevant urban C-ITS results and material i.e. CIVITAS, ELTIS etc;** ➢ **Promote and support the adoption of the standardisation recommendations defined in section 6.5.5;** ➢ **Facilitate the development of common C-ITS services and use case descriptions and common C-ITS services specifications that can be easily understood by local authorities and tailored to their needs and requirements;**

[39] At the point of drafting the official call was not launched
[40] http://www.ertrac.org/uploads/documentsearch/id48/ERTRAC_Automated_Driving_2017.pdf

For the European Commission

- **Host forums of discussion between Member States, industry and urban stakeholder representatives on the topic of automation in urban areas.**

For Member States

- **Develop National C-ITS Policy Frameworks that:**

  (1) define a coherent roadmap, with appropriate financial and technical support for local authorities to invest in C-ITS related to local urban transport and mobility schemes;

  (2) establishes a nationwide C-ITS stakeholder network to exchange best practise amongst all relevant national public and private stakeholders starting from local authorities;

  (3) define a common framework for data sharing and usage amongst all relevant national stakeholders incl. local authorities;

  (4) Match and support local C-ITS strategies;

- **Facilitate national research and pre-deployment of C-ITS activities taking into account the research recommendations defined in section 6.5.3;**
- **National Research Bodies should take into account the research recommendations defined in section 6.5.3.**

For Local Authorities

- **Define C-ITS deployment strategies within the framework of Sustainable Urban Mobility Plans as well as Sustainable Urban Logistics Plans, incl. the coordination of all urban stakeholders across passenger and freight and identify required additional resources[41];**
- **Participate actively in European and National research and pre-deployment C-ITS activities and test range of C-ITS services including the additional urban services defined by the WG;**
- **Identify migration path requirements towards large scale deployment and market uptake of C-ITS solutions for C-ITS suppliers and specify local requirements for C-ITS service providers, where relevant, taking into account legacy systems and solutions existing locally;**
- **Showcase and communicate to citizens the concrete impact and benefits of C-ITS.**

[41] Encompassing commercial & touristic hubs and ports

For Public Transport Authorities and Operators

- Further explore how C-ITS can enhance public transport operations incl. identifying relevant C-ITS public transport services and required standardisation in relation to local policy objectives;
- Participate in European and National research and pre-deployment C-ITS activities (to receive information on best practice implementations, business cases and possible investment costs as a basis for exchange with policy leaders and authorities);
- Strongly engage with local authorities and support the development of local C-ITS deployment strategies.

For European Standardisation Organisations

- Address the standardisation recommendations defined in section 6.5.5.

For Industry

- Suppliers to analyse and evaluate the technical and operational urban deployment barriers defined in Annex I;
- Suppliers to support local authorities migrate to C-ITS systems and services with clear migration/transition paths that address local authority challenges and requirements;
- Suppliers to address the standardisation requirements set out in section 6.5.5 as well as interoperability aspects;
- Service providers, incl. cooperation with local authorities, to ensure service interoperability and sustainability;
- Service providers to analyse and evaluate the additional urban C-ITS services defined by the Urban WG and discuss with local authorities and develop further functions and services to support local policy objectives and multimodal travelling.

For C-ITS Initiatives/Platforms

- Cross-border C-ITS deployment initiatives (in particular C-ROADS Platform) should ensure a greater involvement of local authorities and address the urban application of C-ITS including urban profiles and common service definitions and specifications;
- Ensure systems and services standardisation and interoperability;
- Ensure the exchange of best practise and collaboration between relevant initiatives incl. the transfer of knowledge, legacy and network of completed projects and new ones;
- Address the research recommendations defined in section 6.5.3;

For C-ITS Initiatives/Platforms
➢ **Further promote the development of urban C-ITS services that facilitate sustainable and integrated transport and support local policy objectives and fulfil the needs and requirements of urban stakeholders;** ➢ **Avoid the duplication of similar projects and results.**

6.7. Annexes

Urban Annex I – Urban C-ITS Deployment Barriers

Urban - Annex II – ITS vs C-ITS

Urban - Annex III – Urban C ITS Services

Urban - Annex IV – Urban Automation Scenarios

7. Working Group – Business Models

7.1. Introduction

7.1.1 Background

The deployment of C-ITS cannot just rely on public funding and requires the involvement of stakeholders from different industries and the public sector. To give sufficient confidence to the core stakeholders to invest, the decision to deploy C-ITS has to be based on sound and convincing business cases for all the actors along the value chain.

The cost-benefit analysis carried out in the first phase of the C-ITS Platform clearly showed that the potential benefits of C-ITS strongly outweigh the costs, but also that these benefits will only materialize over time, and depend strongly on coordinated and accelerated deployment (see Figure 4: Net Benefits from C-ITS, source CBA C-ITS platform Phase 1). Also, a large part of these 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.

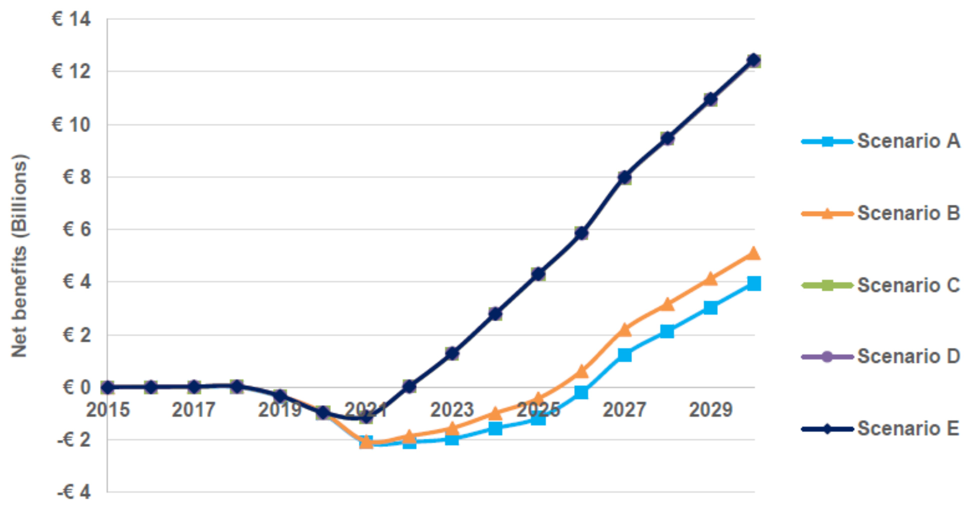

Figure 4: Net Benefits from C-ITS, source CBA C-ITS platform Phase 1

A measurement of the competitive position of national and international businesses involved in the ITS sector (ITS, C-ITS and cooperative adaptive driving) in the Netherlands[42] [Decisio, 2016] revealed the following:

- ITS businesses still depend too much on public funding. The interviewees stated that is due to the fact that the ITS market is not yet truly a mature independently operating market and it cannot operate without governmental support.
- The transition of C-ITS products from the testing phase to maturity for deployment is not obvious. This gap needs to be bridged.

A sound and shared (common understanding of a) business model for C-ITS is thus needed, which reduces uncertainties and in which value is created for all stakeholders that have to invest.

The deployment of C-ITS and other technologies (e.g. Mobile Internet, Internet of Things, Cloud Technology, Automated Vehicles) are relevant in moving towards connected, cooperative and automated mobility, and can be transformative and disruptive to existing business processes.

The Working Group on Business Cases of the first phase of the C-ITS platform set out to identify enablers and address barriers to the development of business models for C-ITS, but it was decided to postpone further analysis to phase II, as it was needed to first take the

[42] Decisio, 2016, Monitor concurrentiepositie ITS 2016 (Monitor competitive Position ITS 2016), carried out for Connecting Mobility, the Netherlands.

outcomes of Working Group 1 (cost-benefit analysis) and Working Group 9 (implementation issues) into consideration.

In order to identify a starting point for potential business models, the motivation of different stakeholders should be considered. An initial distinction can be made between the motivation of public and private stakeholders.

Public stakeholders start exploring the value of C-ITS services primarily from a societal point of view. The improvement of road safety, more efficient traffic flow, more reliable transport and less environmental pollution are typical motivations that represent the achievement of the common good.

The motivation of private stakeholders is often primarily focused on exploring business potential. They compete for customers on products and/or services in order to realize profits, penetrate markets, maximize revenues etc.

However, in realising this business potential, private stakeholders also contribute to fulfilling the common good, e.g. “to improve safety” or to "reduce congestion by recommending alternative routes to customers". The common good is typically achieved on top of commercial goals and is often embedded in the Corporate Social Responsibility (CSR) of firms.

In a similar way, public stakeholders can use improved traffic management through C-ITS to deliver their responsibilities in a more productive way, which represents a promising approach to cope with increasing pressure on public budgets.

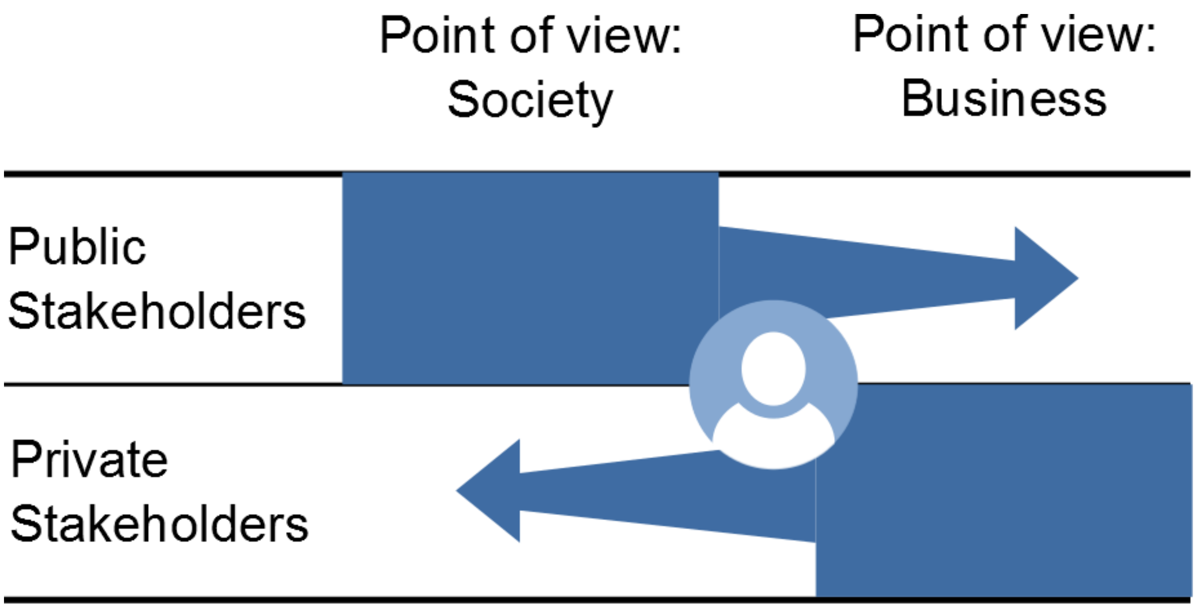

Figure 5: Stylised motivation of C-ITS stakeholder groups

Thus, despite different starting points there is a significant overlap in motivations (see Figure 5: Stylised motivation of C-ITS stakeholder groups) which provides a sufficient basis for exploring the co-creation of the ecosystem around C-ITS and the collaboration on the value network through which C-ITS services are delivered.

7.1.2 Objectives of the Working Group

The objectives of the Working Group were to:

- **Raise awareness of different business models for C-ITS services.** The variety of stakeholders needed to realize deployment of C-ITS can result in various different approaches to business models. Behind these business models are implicit or explicit positions that can be absolutely necessary to, important but not necessary for, or nice to have for a certain stakeholder.

- **Investigate interest in and mutual understanding of business models**. It is important to get a sense of the deal-breaking issues behind each stakeholder's position, without revealing proprietary secrets. The feasibility of cooperation can be investigated by using the knowledge of what is critical, important and nice to have for the relevant stakeholders in the eco-system.

- **Explore process for creating a business model for the C-ITS eco-system.** The feasibility of stakeholders working together in an eco-system relies on the ability to develop the business model. Currently, there is little experience in developing such a model, with a few exceptions such as SCOOP@F and NordicWay. A process is needed to guide the stakeholders involved.

- **Identify barriers and / or issues to address.** Efforts in the first phase of the C-ITS Platform (and elsewhere in Europe) in the area of Business Models have shown that it is not obvious which Business Models are available and can or should be used. Barriers and issues are identified so that actions can be taken to develop Business Models and accelerate deployment.

7.1.3 Organisation of Work

WG Horizontal Issues: Business Models held 6 meetings from September 2016 to July 2017. In addition, teleconferences were held in a small analysis team to prepare the documents and analysis presented in the Working Group meetings.

DG MOVE, as chair of the Working Group, took care of organizing WG meetings and teleconferences and maintaining relations with other Working Groups of the C-ITS platform.

All results, outputs and expert recommendations of the C-ITS Platform Working Group Business Models have been prepared and discussed by the nominated experts representing the organisations and countries listed in "C-ITS Platform Phase II Annex I WG Participant Lists", annexed to this report.

In recent years several initiatives aiming at deploying C-ITS services have been set up. An important starting point for the Working Group was to bring together insight from those initiatives, the related services and the business model considerations behind them. This initial exchange included business model considerations from the Member States cooperating in the C-ITS Corridor (The Netherlands, Germany and Austria), SCOOP@F (France) and NordicWay (Finland, Sweden, Norway and Denmark) as well as perspectives from private companies.

Based on these initial exchanges, five possible tracks were determined to identify enablers and address barriers to the development of business models for C-ITS:

- Build a bottom-up shared view on business models for C-ITS services and raise awareness and provide understanding of geographic and/or sector specific particularities;
- Approach business models from a top-down view of business architecture: based on standards (e.g. ITIL, ISO 17427), to be complemented by the FRAME NEXT CEF Programme Support Action;
- Decompose cost-benefit analysis to provide actor specific accounting of costs and benefits. This also includes the levels of technology platforms and applications;
- Collect industry requirements;
- Consider available inputs from literature for items such as value chain extension, macro-categories of value creation models, incentive categories etc.

The work has embraced all identified tracks but has focused in particular on the first track.

7.1.4 Organisation of this document

This document is organised as follows. Section 7.2 presents how business models for C-ITS are defined in this report and the design approach taken to describe business models for different C-ITS services and ecosystems. Section 7.3 brings together the perspectives of different stakeholders in an analysis of key issues identified. Section 7.4 concludes with recommendations and follow-up actions.

7.2. C-ITS business models: definition and design approach

The working group established a consensus definition for a business model, which is suitable in the C-ITS context:

A Business Model describes the way in which organizations produce and deliver value to their customers/consumers

It is clear that the C-ITS market is a dynamic market that will need progressive investment over several years, and that at this moment it is not yet feasible to fully integrate quantitative financial features (revenues, costs, profitability) when describing the business model.

Thus it was decided to limit the business model design of C-ITS to a qualitative description at this stage. The quantitative features are more about the business plan, which uses the business model as a foundation.

It was also clear that a business model for C-ITS needs to be adaptable to its environment, that the system scope needs to be adapted over time and that stakeholders (and the relations between them) need to be integrated according to that scope.

It was determined that the value chain model and the value network model (and their combination) were most useful to describe and discuss C-ITS business models with multiple stakeholders.

The business canvas model was considered too static and too focused on individual stakeholders for this purpose; although it can be a good support to highlight internal and external components of a business model and be used as a checklist to make sure that the business model for the whole ecosystem is captured.

Next, an enabling exercise was performed which consisted of mapping the information flow between different actors in the provision of several C-ITS services using the value chain and value network models. Below two examples are presented, while more details and services descriptions are included in Business models – Annex 1.

This enabling exercise formed the input for the discussions in the WG and the analysis in section 7.3.

The value chain model

Generic value chain for traffic information incl. detailed process steps		Content provision												Service provision												End User
		Content Collection						Content Processing						Service Provision						Service Presentation						
Road Works Warning (Short Term) - Germany - ETSI ITS G5		Detection	Data delivery	Data reception	Data pre-processing	Data delivery	Commu-nication	Data reception	Content fusion	Data processing	Quality check	Content delivery	Commu-nication	Content reception	Content fusion	Service generation	Pre-formatting	Service delivery	Commu-nication	Service reception	Service decoding	Info fusion	Service rendering	Service presentation		
Roles	**Example Actors**																									
R-ITS-S Operator	Hessen Mobil	X	X (IRS)	X	X	X																				
C-ITS-S Operator	Hessen Mobil							X	X	X	X	X		X	X	X	X	X	X							
Communication Provider	Telekom, Unity Media, fixed cable			X			X						X													
Service Application Provider	TomTom, INRIX, Here																									
V-ITS-S Operator	Volkswagen, Opel ...																		X	X	X	X	X	X		
TCC Operator	Hessen Mobil					X (Road Works Manage-ment System)																				
Road Infrastructure Operator	Hessen Mobil	X	X (Road Works Safety Trailer)																							
Infrastructure PKI Operator	tbd																									

Figure 6: Road Works Warning (short distance) in Germany with ITS-G5 implementation

The value network model

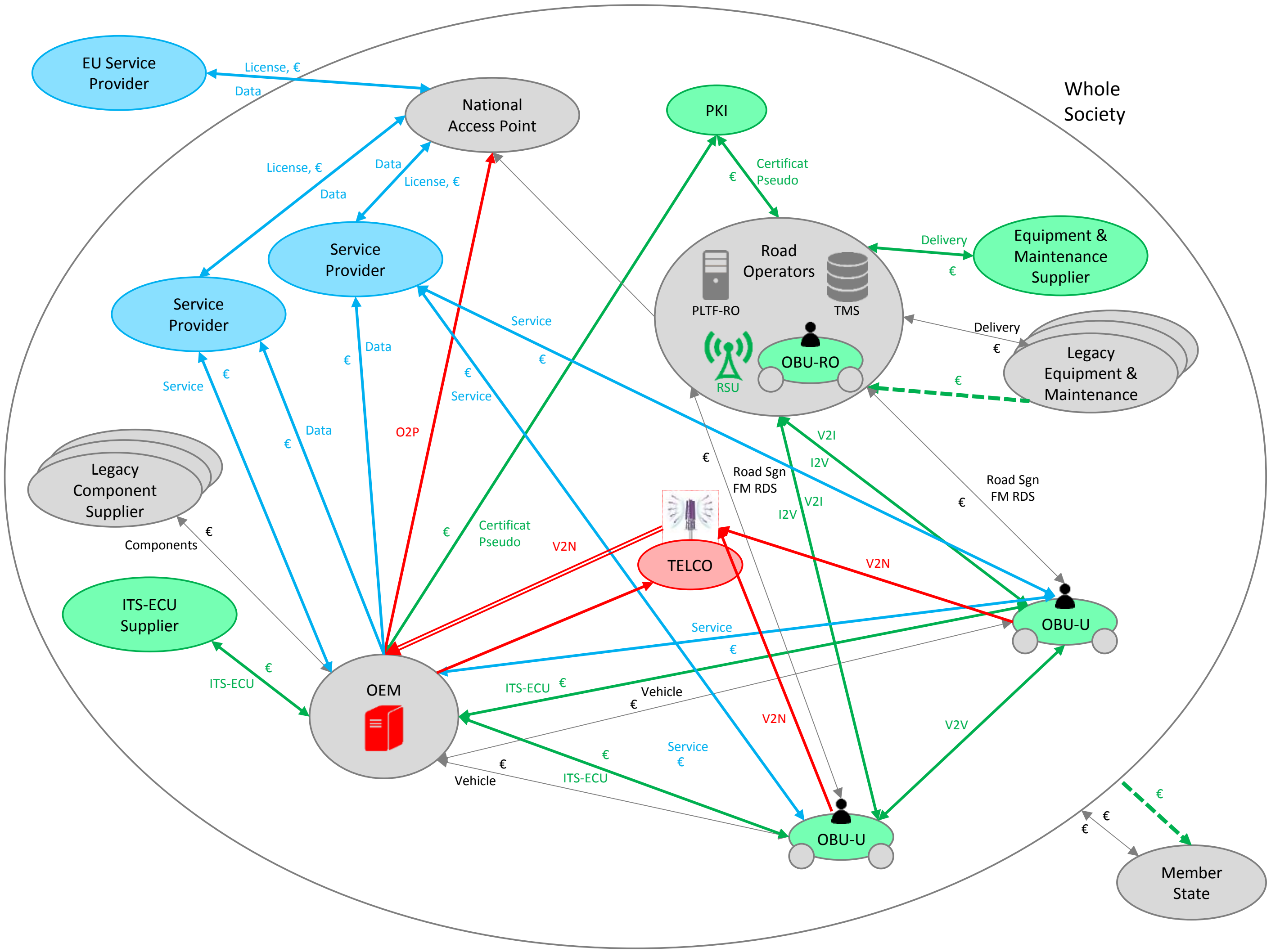

Figure 7: Global organization of SCOOP@F

7.3. Stakeholder perspectives and key issues identified

To support the business model analysis and identify key motivations and issues for each stakeholder group in deploying C-ITS, the Working Group developed a description of C-ITS business models from various stakeholder perspectives, which is presented in Business Models - Annex 2. These stakeholder perspectives are those of public road authorities, private road operators, city authorities, service providers, vehicle manufacturers and end users. Most input was provided by stakeholders based on the projects they are directly involved in. This was completed by an interpretation of other stakeholder perspectives that were deemed particularly important.

The perspectives originate from different participants, and although they were discussed and commented by the WG, they can remain conflicting on points. Likewise, the perspectives cannot and do not pretend to represent the opinion of complete stakeholder groups.

Based on the individual perspectives, the Working Group then identified a consolidated list of key motivations and issues for each stakeholder group in deploying C-ITS. Consistency with the results of the first phase of the C-ITS Platform (in particular WG8 – Acceptance factors) was checked.

The table on the next page presents an overview, with the motivations and issues presented as key words to ease reading. This is followed by a concise discussion of the motivations and issues. Recommendations to address these issues are covered in section 7.4.

It should be considered that the analysis of this working group is based on a small group of active C-ITS stakeholders, who do not represent their entire stakeholder group, and that several stakeholder groups were not yet involved in the process. This is consistent with most C-ITS projects to date, which often primarily involve stakeholders supporting investments and direct business.

However, stakeholders include all actors involved in the deployment of C-ITS, and also those impacted positively or negatively by C-ITS. One example are car insurers: they are expected to have less cash out (damages fatalities) and thus can benefit positively from the deployment of C-ITS, but they have not yet been involved in discussions/projects.

For the further development and refinement of C-ITS business models it is critical to engage with a broader group of stakeholders.

		Actors			
		Public Authorities	Private Road Operators	Service Providers	Vehicle Manu-facturers
MOTIVATIONS	Customer/business value		X	X	X
	Better informed users & customers	X	X	X	X
	More cost-effective provision of road infrastructure / traffic management	X	X	X	
	Increased revenues / profitability		X	X	X
	Public road safety	X	X	X	X
	Safety of road maintenance personnel	X	X		
	Traffic flow	X	X	X	X
	Journey time reliability	X	X	X	X
	Environmental benefits	X	X	X	X
ISSUES	**How will we determine costs & benefits of C-ITS?**				
	Evidence base investment costs and savings	X	X	X	X
	Evidence base operation and maintenance costs and savings	X	X	X	X
	Evidence base social impact	X	X	X	X
	In-vehicle vs road-side service effectiveness	X	X	X	X
	New business opportunities, but also new entrants/competitors	X		X	X
	Sufficient benefit/cost ratio or return on investment	X	X	X	X
	How will services be financed?				
	Pricing of services to the final customer	X	X	X	X
	Balanced service level provision (highway/urban/rural)	X	X	X	X
	Data provision compliant with ITS directive delegated acts b & c	X	X	X	X
	Pricing of data and information exchange	X	X	X	X
	How will the delivery of services be realized?				
	Conditions for access to in-vehicle data	X	X	X	X
	Data privacy & Anonymity	X	X	X	X
	Data security	X	X	X	X
	Interoperability across Europe	X	X	X	X
	Use of technical standards	X	X	X	X
	Lack of relevant skills in infrastructure planning	X	X		
	Guidelines and manuals (digital, C-ITS)	X	X		
	Forming the governance layer of C-ITS	X	X	X	X

7.3.1 Motivations

Road safety, fluent traffic flow, reliability of journeys and reducing environmental impacts are important motivations for all stakeholders. With regard to road safety, the safety of maintenance personnel is a specific motivation for the road authorities and operators.

For the individual user, traveller or haulier, a key motivation is likely the added value that the service brings. This can be, for example, a business value to a haulier or an entrepreneur, or a comfort value to a commuter. A specific motivation is to be better informed so that one can make better decisions or avoid making mistakes in, for instance, route selection.

Especially for the road authorities and operators living under constant pressure to minimise costs while still providing reliable network operation, there is a core need to aim for maximum cost-effectiveness in network operation and traffic management.

For private sector stakeholders, a major motivation is to increase revenues and enhance the profitability of operations.

7.3.2 Issues

How will we determine costs & benefits of C-ITS?

One of the major issues is how to determine the costs and benefits of C-ITS. The public sector stakeholders are responsible provide value for every euro invested in their activities to the tax-payers and the private stakeholders to their owners and shareholders to. There is a clear progression from determining benefits and costs of C-ITS, to calculating Benefit-Cost Ratios, and finally public and private stakeholders developing shared Business Models. This means that there is a need to provide hands on, concrete evidence on the investment, operation and maintenance costs as well as the savings on these costs as a result of C-ITS services and infrastructure.

Similar evidence is needed for the impacts and social benefits involved, preferably from different individual projects as impacts can be different from one country to another according to cultural specificities and different operating environments. In the end, all stakeholders involved need to be sure they can get sufficient benefit/cost ratio or return on investment for their involvement in the C-ITS value network, and thus there is a need for easily replicable, broadly accepted and evidence based material and methods for making sound investment decisions.

A specific case for traffic management and information services is to determine whether it is more efficient to provide services via roadside signs and systems or via in-vehicle displays and equipment. Experiments and simulations are needed to get a better understanding of this topic.

The emerging C-ITS services will also provide new business opportunities and give rise to new services and related benefits, but this can also result in new entrants and competitors to the field, which in turn is an issue for the current stakeholders. Current stakeholders can mitigate the threats by actively participating in the development of C-ITS services and their requirements as well as forming alliances with promising new stakeholders.

The current and up-coming deployment projects should make a cost-benefit analysis covering their whole eco-system. This analysis should consider investments made by every stakeholder, cash flows or savings, and capital cost while keeping in mind a need of consistency from one project to another. As many stakeholders can be reluctant to share their investment and cost data, some parts of the analyses could be restricted. For comparisons between projects, the business model description of each project should use similar frames - for instance as done for the analysis in this report - to form a good basis for comparing all projects, considering that not all projects have made the same choices, for example regarding the technologies supporting C-ITS (ITS-G5, Cellular network).

How will services be financed?

It is important that all stakeholders (commit to) provide data compliant with the ITS Directive and its delegated acts. Cost-benefit analyses should further investigate whether C-ITS are profitable for involved stakeholders, considering also a sufficient return on investment, with safety services being provided "free of charge" at the point of use for the final customer (which does not mean however that C-ITS services have to be provided free of charge).

Considering the balanced service level provision between different regions / environments, it seems clear that C-ITS is first deployed in areas where the effects will be greatest (for instance based on number of accidents, or the level of traffic) as profitability and the quickest return on investment will likely be achieved there, and most evidence for costs & benefits will be gathered as well. To determine possible costs & benefits on a local level, the analysis of deployment projects should be granular, looking not only at effects at the national level.

How will the delivery of services be realized?

There is a huge gap in knowledge between those who have been involved in research and innovation and those who are expected to be responsible for investments in large-scale C-ITS deployment. Thus, there is a need for increasing the (C-) ITS competences among infrastructure planners. Action must be taken to develop methods and tools for raising the knowledge level within the C-ITS area, and specifically to increase the expertise of employees in departments for long-term planning and investment. The transformation to a European transport system that benefits from digitization possibilities such as C-ITS requires large investments of such nature that it must be included in government supported long-term infrastructures plans.

Investment activities, especially in the public sector, are strongly guided by guidelines and manuals. Therefore, the existing documents must be updated based on digitalization and C-ITS capabilities.

The final implementation of several key aspects of C-ITS (such as access to in-vehicle data, data privacy & anonymity, data security, interoperability and the use of technical standards) will have strong implications for business models. These topics are being addressed primarily in other fora. However, it is important that business model issues are considered in those discussions as well. For the business model, data and the rights and conditions for its access are of utmost importance.

The issues described above point towards the need to organize collaboration between the C-ITS actors. In order to provide a fundament of legal certainty for cross sector collaboration, a governance layer for C-ITS services has to be formed. The bandwidth of possible institutional arrangements can range from dedicated institutions (to be established) to shared sets of rules (e.g. codes of conduct, codes of practice).

In other Working Groups of the C-ITS Platform, it has become evident that bodies are needed to take care of policy development, specific aspects of service operation and "system" supervision. The Working Groups aim at designing the government layer suitable for the WG scope, in other words, to conceptualise it bottom-up. From the perspective of the Horizontal Issues WG it is important to make sure that the recommendations converge to a common governance picture. What exactly is appropriate at what level is still to be worked out: for instance, in a follow-up phase of the C-ITS Platform, or in the preparation of (a) Delegated Act(s) on C-ITS.

7.4. Recommendations and Follow-Up Actions

This section presents the recommendations from the experts.

1. Report on benefits and costs of C-ITS

While several studies have investigated the benefits and costs of C-ITS, these have almost always been either desktop ex-assessments, simulations, simulator studies or very restricted field trials.

All C-ITS deployment projects and pilots should be recommended and where possible required (such as in EU and nationally -supported projects), to report on the costs, impacts and benefits of the C-ITS services piloted and deployed. While doing this they should utilize the guidance on evaluation provided by the C-ROADS platform and EU EIP project.

A separate action is needed to compile the cost, impact and benefit data produced by these projects and provide a synthesis of the results including their transferability to different conditions and environments.

The allocation of costs and benefits between the various stakeholders should also be included in the assessment, for instance by utilizing the value network or chain models. The data on costs and benefits should be used for the refinement of business models.

2. **Form the governance layer of C-ITS and determine the development and common costs associated with the delivery of services**

The governance layer of C-ITS will comprise at least a triad of institutions responsible for policy setting, shared aspects of service operation and “system” supervision. These institutions have either to be designed and established or the roles of already existing institutions have to be suitably enlarged.

The elements of the governance layer come along with development and common costs to be shared by the actors. These costs, such as the contribution to the development of technical standards and the PKI infrastructure and maintenance, which form a required layer in the service provision, need to be estimated. Data needs to be gathered, both within and outside projects, keeping track of the parties and activities incurring these costs. The results should be used in the refinement of business models.

3. **Agree on access to data for C-ITS services**

C-ITS (and cooperative, connected and automated mobility) hinges on data – the data from vehicle sensors, infrastructure sensors, users and back-office systems as well as the artificial intelligence and analytics managing, fusing and refining the data in addition to the packaging and presentation of the data to the users.

The data are owned or governed by a number of different stakeholders. Access to all relevant data will facilitate not only C-ITS services but also a number of other services, with considerable economic value. For this reason, the stakeholders did not agree on access to data during the first phase of the C-ITS platform, and since that, some stakeholders have produced their own position papers and some specific groups have discussed these issues.

A new attempt should be made to have all relevant public and private stakeholders in Europe around the same table to find an agreement on access to data, including business model-related questions of national or European data licenses, formats, interfaces, addressing privacy concerns etc. The easiest starting point seems to be safety-relevant information, which is crucial to most Day 1 C-ITS services. After that, traffic management related information could be a second choice to work on. In addition to agreement on access to data, an action plan to establish access to data also in practice should be developed and then implemented. Standardization of the data formats for all data at the National Access Points should be established.

4. Establish quality levels for data

Established quality levels limit potential risks to all parties in their business models. Data provided to National Access Points and in-service delivery should have an agreed (minimum) level of quality. The quality requirements should be defined using the quality framework developed and maintained by the EU EIP project. These quality requirements address level of service (geographical coverage and availability) and level of quality (timeliness, latency, location and reporting accuracy, correctness of classification, and events and report coverage).

Parties accessing or receiving the data then know the level of data quality that they will receive. Since quality could be characterized through several quotations (one for each criterion used to define quality), each party may not need to know the detailed characterization. A service provider may need to know the detailed quotation, however, a final user might just need to get a synthetic indicator (for instance 1: low quality; 2: medium quality; 3: high quality). As a consequence, and according to consistency considerations across whole Europe, one might also specify:

- which granularity each party should receive about data quality,
- the method to determine the values for non-detailed quality indicators (such as a synthetic indicator), on the basis of a detailed quotation.

7.5. Annexes

Business models – Annex 1

Business models – Annex 2

Business models – Annex 3

II - Beyond C-ITS, towards Connected, Cooperative and Automated Mobility

8. Working Group – Road Safety

8.1. Objectives of the Working Group

The group was requested to make a qualitative assessment aimed at identifying road safety issues that need to be addressed in relation to the deployment of Day 1 and Day 1.5 C-ITS services[43] and possibly recommend action to authorities and stakeholders.

The aspects to be addressed in this assessment are the following:

- **Priority C-ITS services from a safety point of view**: Make a qualitative prioritization for C-ITS services in relation to safety.

- **Technical issues:** For C-ITS services considered being relevant for safety the group discussed various technical aspects. Examples include the readiness (availability of standards, detailed specifications) or reliability.

- **Human Machine Interaction:** The group discussed which HMI issues required attention and addressed questions like:

    - Can all users interact/understand the information from C-ITS services?
    - Is there a need for harmonisation or standardisation?
    - Will HMI influence the way users perceive/use C-ITS?

- **Driver behaviour:** C-ITS services, particularly those considered safety-relevant, may influence/change the behaviour of road users, be it the driver of the equipped vehicle, but also the drivers of other vehicles, including motorcycles, and cyclists or pedestrians.

- **Traffic rules:** As a result of the deployment of C-ITS services some traffic rules may need to be adapted. The group discussed whether this was the case and tried to identify them.

The objective was to agree on conclusions and recommendation for action on the aspects listed above.

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[43] As listed in the Commission Communication COM(2016) 766 final and defined in the C-ITS Platform report Phase I

8.2. Organisation of Work

The group, composed of representatives from various areas, met seven times between October 2016 and July 2017. The discussions were illustrated and informed by presentations from the members. Group members provided written contributions on the basis of a template provided by the Commission.

Based on the presentations and the written contributions the method was an open discussion focused on the topics listed above.

For the prioritization of C-ITS services in relation to safety the members of the group were requested to rate them with a qualitative scale (low medium high) on the basis of their expert knowledge.

All results, outputs and expert recommendations of the C-ITS Platform Working Group Road Safety have been prepared and discussed by the nominated experts representing the organisations and countries listed in "C-ITS Platform Phase II Annex I WG Participant Lists", annexed to this report.

8.3. Conclusions

- Cooperative Intelligent Transport Systems (C-ITS) have been assessed in various studies and projects as capable of contributing substantially to road safety, reducing the number of road fatalities by preventing vehicle collisions. (e.g. SIM^{TD} Test Field Germany[44]).

- C-ITS safety functionality has undergone intensive testing and continuous improvement involving road and traffic operators, vehicle and equipment manufacturers, ITS industry etc.

- The potential of C-ITS for contributing to road safety has become even more apparent with the current connected and automated driving (CAD) developments. These developments should be combined and strengthened.

- The technology for C-ITS Day 1 and some Day 1.5 safety applications is mature enough to significantly contribute to the prevention of vehicle collisions. Vehicles and drivers can be better informed about unexpected situations and negotiate safe interactions with other vehicles in their surroundings. Research, innovation and development have shown their safety potential.

[44] SIM^{TD} Test Field Germany : http://www.simtd.de/index.dhtml/enEN/backup_publications.html

- C-ITS applications that have been tested and have a proven record of safety benefits should be deployed without further delay.

- C-ITS applications that are already available, especially those with a high cost-benefit ratio, should be prioritized

- Strict budgetary constraints, faced in Member States across the EU, make it difficult to invest in changes of the infrastructure unless they bring short-term benefits and the authorities see continuity in the European Commission's plans for gradual C-ITS deployment.

- Society should take out as much safety potential as possible, as early as possible, from C-ITS and automated driving. This would also make the European automotive and transportation industry globally competitive.

8.4. Recommendations and Follow-Up Actions

8.4.1 General

- In order to harvest the expected safety benefits of C-ITS, the EU should encourage C-ITS services for all vehicles and road users, ensuring interoperability amongst the different players to facilitate a fast European-wide deployment.

- The C-ITS stakeholders should work together with the World Forum for the Harmonisation of Vehicle Regulations (WP29)[45] and the Global Forum for Road Traffic Safety (WP1)[46] to promote the implementation of C-ITS for safety purposes.

- The European Commission should define a clear set of short-term targets for C-ITS EU-wide deployment, which starts in 2019.

- The European Commission should define a timeline with enabling actions, listing steps that will be taken in order to assist Member States and other stakeholders in implementing C-ITS services.

- The European Commission should further encourage deployment and initiate new ambitious innovation projects and pilots involving stakeholders such as vehicle manufacturers, system suppliers, road authorities, insurers, research institutes and universities to address and implement the required and necessary functional issues of C-ITS services for safety purposes.

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[45] https://www.unece.org/trans/main/wp29/meeting_docs_wp29.html
[46] https://www.unece.org/trans/main/welcwp1.html

- The European Commission support is very important and must be further extended with services, which are currently already recognized by the European Commission C-ITS Platform Phase II, by automation initiatives and by the different stakeholders.

- The European Commission has initiated the creation of a single point of reference for the interoperability of Day 1 C-ITS services, the C-Roads platform. This initiative should be extended to cover Day 1.5 C-ITS services and related interoperability. The interoperability should be formalised [standardised].

8.4.2 Priority C-ITS services from a safety point of view

- C-ITS services with the higher safety potential should be prioritized

- Based on research available so far and in accordance with the qualitative assessment of the group, the Day 1 services which have highest safety potential for cars, buses, goods vehicles and powered two-wheelers are:

    - In-vehicle speed limits (including dynamic speed limits),
    - Emergency electronic braking light,
    - Road works warning,
    - Weather conditions,
    - Hazardous location notification

  plus the Day 1.5 services:

    - Intersection safety
    - Vulnerable road users protection

- In order to support safe traffic management it is essential that probe vehicle data is available to traffic managers

- V2V applications are expected to bring considerable safety benefits for VRUs[47], in particular for powered two-wheeler at intersections such a Motorcycle Approaching at Intersection.

- C-ITS services specifications need to be adapted to the different categories of road users and in particular VRU and their characteristics.

[47] Kühn, M., Lindenau, M. :Intelligent systems for improving motorcycle safety, Compact accident research 45, German Insurers Accident Research, 7/15/2014, Berlin

- As concluded by the working group on cost-benefit analysis, deployment should give priority to low cost solutions, which can bring immediate safety benefits.

- If a service delivers large safety benefits, then it would make sense to have it available on all vehicles. Assess whether there is a safety case for retrofitting existing vehicles, possibly limited to certain vehicle categories.

8.4.3 Technical Issues

- C-ITS functionality must become part of a compliance and certification process to ensure minimum standards of performance and some consistency of behaviour across the market.

8.4.4 Human Machine Interaction (HMI)

- Human-machine interaction must be addressed in a comprehensive manner. In particular, the in-vehicle human-machine interface should be designed to integrate all interactions between the vehicle and the driver.

- This means human-machine interaction for the various C-ITS services cases must be considered in conjunction with any other vehicle systems, which require interaction with the driver, in particular safety systems.

- The underlying principle for the design of human-machine interface should be a safe operation of the vehicle.

- HMI, in particular for C-ITS systems, should be tested and designed taking into account the human capabilities.

- When warning of a dangerous situation, the information provided to the driver should be limited to the minimum necessary for understanding and taking adequate action in the available timeframe. C-ITS messages should not distract the driver, especially while managing an emergency manoeuvre.

- Timing of alerts is a major parameter in C-ITS safety potential. It should be adapted to the emergency of the situation. Messages should be provided early enough for the driver to be able to react in the proper way.

- It should be assessed if, for emergency (time-critical) use cases, C-ITS messages should provide the driver with information only on his/her expected behaviour (what to do).

- All HMI messages should be compatible with on board systems and their display priority should be managed jointly.

- Human-machine interfaces should be designed in such a way that any licensed driver is able to effectively and safely use them in any vehicle. As a consequence of this, HMI functionalities for safety time-critical situations should be harmonised: pictograms' form, colour or positions, auditory warnings sounds, haptic warnings

- Further research should deepen the understanding implications of C-ITS on driver awareness and define an acceptable driver workload as well as measures to limit system dependency.

8.4.5 Driver behaviour

- Driver behaviour may change as a result of the deployment of C-ITS applications or any other driver assistance features or CAD functionalities.

- Some of the changes in driver behaviour could take the form of 'compensation effects', which are likely to appear. In order to mitigate them, C-ITS services and other safety applications should contemplate the possibility to be adjusted (or to self-adjust) to the users' driving style, always within safe limits.

- Consideration should be given to the effects higher levels of assistance and automation will have on driver's skills and how they may react if systems fail or are unavailable.

- Driver training, testing and licencing should be adapted and continuously updated to the development of new technology features in vehicles. Drivers should be aware of the safety features their car is equipped with.

- Vehicle manufacturers should provide appropriate consumer information about the C-ITS technologies installed in their vehicles.

- An assessment should be made of the possible risks incurred by the mix of C-ITS equipped and non-equipped users who will be sharing the road for the foreseeable future.

8.4.6 Traffic rules

- Traffic rules may in some cases need adaptation. This is not a consequence derived exclusively from C-ITS services, but also from the deployment of driver assistance systems and automated driving functions.

- If traffic rules are adapted, such adaptation should be coherent in all Member States' traffic rules, so that C-ITS services and any other functionality approved for deployment in the EU may be effectively used in the same manner without breaking the rules of behaviour.

9. Working Group – Physical and Digital Infrastructure

9.1. Introduction

The impact of Connected, Cooperative and Automated Mobility (CCAM) on the physical infrastructure includes new requirements imposed on road planning, construction and maintenance to help unlock maximum benefits from this new technology but also the opportunity that existing practices may no longer be necessary in the long term when the majority of vehicles on the road will be characterised by a high degree of connectivity (e.g. induction loops for detecting vehicles, optimisation of lane widths and better road design, also allowing more safe space for other road users).

Road infrastructure is traditionally seen as concrete and asphalt, road signs and traffic lights, bridges and tunnels, in other words physical infrastructure, but today this is complemented by the digital infrastructure, such as digital mapping and real-time traffic information. The digital infrastructure in future should then be seen as an accurate, dynamic and live digital representation of the physical infrastructure and its traffic conditions, including additional information which cannot or is not presented by the physical infrastructure. Such digital infrastructure will greatly support connected and automated vehicles and other road users into understanding their surroundings and is potentially much more cost effective than extensively modifying both the physical infrastructure and equipping vehicles and other road users with an array of redundant sensors. This digitisation shall improve the safety on the road and also brings new possibilities in dynamic traffic management; it is for example far easier to introduce variable speed limits (e.g. in case of road works or to tackle shockwaves).

So whilst the opportunities are clearly recognised many (new) questions are raised also, such as is every road suited for automated driving? How can physical infrastructure advancements support CCAM and how can CCAM support the physical infrastructure? How can we standardise and harmonize the new features for interoperability (functionally but also organisationally)? How can we secure safety critical digital infrastructure? How can we manage the (very long) transition period in which human driven and automated vehicles will share the road? Who will harmonize the legal aspects of digital road regulations and are changes required in the legal framework? What will we be able to learn from Day 1 deployment of C-ITS for later phases, such as higher levels of automation and Day 2 services?

Many experts in the WG PHYSICAL AND DIGITAL INFRASTRUCTURE are convinced of the benefits and motivated to enable CCAM. The working group collected and structured, early on in an initial workshop, topics which should be considered in the WG. Next, these topics were framed to better understand the interaction between physical & digital infrastructure and CCAM.

Nevertheless, the context in which these topics were discussed needed to be elaborated more clearly. It was decided that the focus should be on specific needs, problems or issues – which could be common to many use cases or situations – where physical and digital infrastructure could support and help create a solution. Experts were asked to detail both the issue and the possible (infrastructure) solution. This paper is created to assist and motivate (and structure) the discussion.

It is acknowledged that often more research is needed to confirm the practical feasibility of the proposed solutions. Considering budget constraints, these solutions will have to be matched with budget estimates and a prioritisation of the most urgent needs in order to provide road operators with good tools for decision making. Finally, after agreement is found on the technical and operational feasibility, in many cases additional aspects will need addressing including stating new roles and responsibilities, changes in regulation, standards, business models etc.

In order to allow smooth functioning of CCAM it is essential that physical and digital road infrastructure is maintained effectively and sustainably across the EU, not only on motorways but also in urban areas. Road infrastructure measures can crucially enhance the performance and availability of advanced driver assistance systems and connected driving use cases, thus contributing to an overall increase in road safety and traffic efficiency. As such, a crucial first step to implement CCAM concerns the preservation, maintenance, restoration and upgrade of existing physical and digital road infrastructure.

To further illustrate and frame the topic a non-exhaustive list of measures that could be envisaged for the physical infrastructure includes the following:

A. For physical infrastructure:

- Decent quality and visibility (contrast) of lane markings, in particular on motorways, dual carriageways and key cross-border routes (TEN-T network) ⇒ this shall facilitate lateral control for automated driving.
- Clear visibility of road infrastructure for vehicle sensors and the driver – including road signs, speed limit signs, traffic signs indicating change of speed limits via marking entrance to towns and municipalities ⇒ frequently, these signs tend to be hidden and somewhat covered by trees, or temporarily by snow, and are not clearly recognisable for vehicle systems at the required distance.
- To present static and dynamic traffic rules (or signs) also in digital representation in data bases, in maps and directly on the road. When using both physical road signs

and the digital infrastructure, mismatches may occur, especially for dynamic signs. Also, sometimes the regulation becomes effective when physical signs have been installed, and sometimes when the regulatory documents are published. Similarly, the digital representation is sometimes based on the regulatory documents, and sometimes by interpreting the physical signs. A higher quality of data and further harmonization of regulation will benefit CCAM.

- Availability of usable hard shoulders ⇒ for safe, automated emergency stops.
- Light-signal systems with communication facilities can, in the long run, contribute to the reliability of digital road infrastructure.
- Variable message signs (VMS) often have scanned LED arrays which are incompatible with vehicle cameras. VMS therefore need standardised triggers (pulsating LEDs and/or short/long range communication).
- Ensuring availability of existing and intact fences where needed on motorways, dual carriageways and TEN-T network to minimize risk regarding hazardous situations with large wild life (such as deer, moose, etc.).
- Identification and communication about platooning levels for a specific road segment statically or dynamically assigned (e.g. amount of vehicles allowed in an platoon)
- Allocation of dedicated lanes or areas where economically viable (e.g. automated shuttles are given access to existing bus lanes)

Similarly, to further illustrate and frame the topic a non-exhaustive list of measures that could be envisaged for the digital infrastructure includes the following:

B. For digital infrastructure:

The digital infrastructure is composed of data bases and geographical data as well as the related back-office functions. It contains both static and dynamic data and connects and interacts with vehicles through hybrid communication equipment incorporating at least short-range and long-range communication systems. Continuous improvement of cellular coverage for longe range communication and deployment of short range communication infrastructure along motorways and urban environments supports tactical and strategic information exchange (e.g. safety and automation related applications) such as:

- Two-way real-time exchange of traffic safety or traffic efficiency related warnings (hazardous situations such as end of traffic jam, dangerous weather conditions, etc.) between vehicles and infrastructure (meaning detection of the hazardous situation and generation of the warning message can come from both).

- Infrastructure-based sensors to detect the different traffic participants and traffic influencing objects, e.g. detecting pedestrians and cyclists at critical intersections and transmitting such information to vehicles.

- Standardised transmission of short-term road construction or accident situations (position, lane/location concerned, time, speed limit, existing lane markings, passing lanes, etc.) supported by Local Dynamic Map (LDM) and high-definition maps (HD-MAPs) concepts.

- Transmission of definitive and binding duration of traffic light status and timing (SPAT) for change to the next signal phase and intersection topology (MAP) information.

- Transmission of right of way rules (traffic light signal, stop, give way, etc.).

- Transmission of (dynamic) speed limits, entrance to urban environments, etc.

- Transmission (forwarding) of the position and operation mode of emergency vehicles and other priority vehicles with right of way permission to ensure traffic prioritisation at intersections, road segments and traffic lights. Transmission of lane closure and traffic light information to influence traffic flow such that prioritized vehicles can benefit from the optimized flow.

These types of data roughly fall into two groups:

- Local, dynamically generated (tactical) data which is mainly used for safety purposes. Messages for this type of information (SPAT/MAP, IVI, CAM, DENM, LDM etc.) is already standardised and well tested in pilots, though updates of these standards may still be needed.

- The other group is strategic data which reflects the more static traffic environment: Road network topology, circulation plans, static signage, rules and restrictions. In short these are traffic regulations. Some of the data sets are partly standardised for broadcast purposes, but most of this at best exist as proprietary databases within the different Member States (see also section 9.4.5).

The different aspects of physical and digital infrastructure and how they roughly map to C-ITS and automation is illustrated below, including the interaction with the vehicles, which is enabled by a hybrid communication strategy (for more details on hybrid see C-ITS platform report Phase I and the EU Strategy on C-ITS). Also note that hybrid communication is part of the standard architecture for C-ITS communications, initial standards for this field have been developed by ETSI/CEN/ISO and have been validated in EC projects over the last ten years.

Requirements coming from new use cases and applications will require updating, detailing and extension of these standards. The need for European interoperability will result in

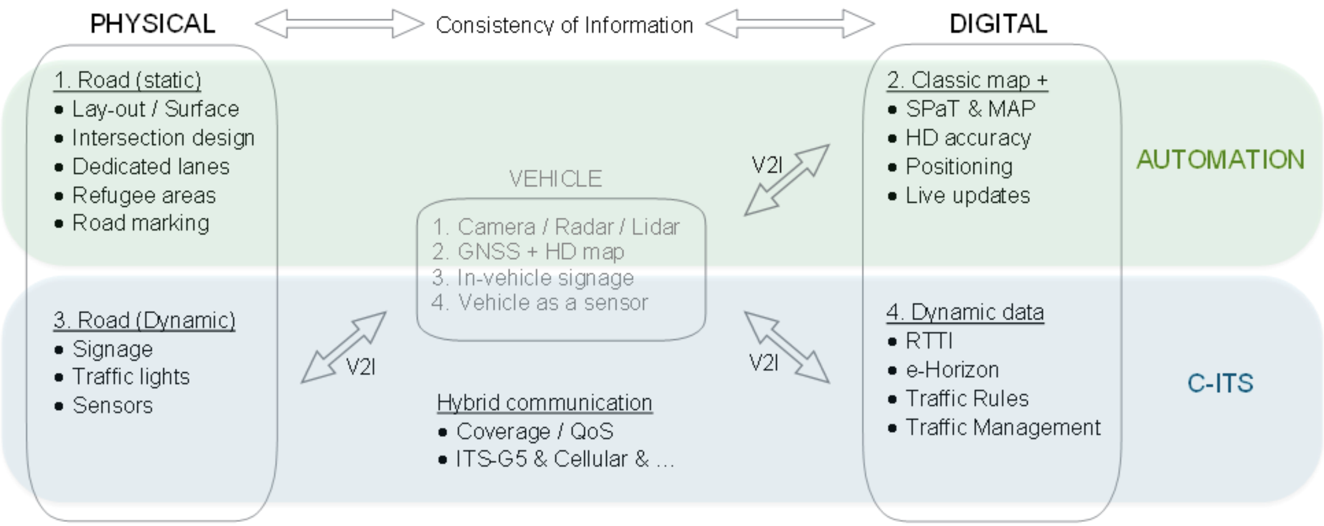

Figure 8: Physical and Digital Infrastructure

further profiling work, as currently taking place in the C-ROADS platform[48].

9.2. Objectives of the Working Group

The many experts in the WG PHYSICAL AND DIGITAL INFRASTRUCTURE are convinced of the benefits and motivated to enable CCAM. But whilst the opportunities of CCAM are clearly recognised many (new) questions are raised also, such as is every road suited for automated driving? How can physical infrastructure advancements support CCAM and how can CCAM support the physical infrastructure? How can we standardise and harmonize the new features for interoperability (functionally but also organisationally)? How can we secure safety critical digital infrastructure? How can we manage the (very long) transition period in which human driven and automated vehicles will share the road? Who will harmonize the legal aspects of digital road regulations and are changes required in the legal framework? What will we be able to learn from Day 1 deployment of C-ITS for later phases, such as higher levels of automation and Day 2 services?

This WG aims to provide recommendations to answer these questions.

9.3. Organisation of Work

The organization of work was based on regular Working Group meetings (a total of 11 meetings took place in Brussels from July 2016 – July 2017 in the course of the second phase of the C-ITS platform).

[48] https://www.c-roads.eu/platform.html

The working group collected and structured, early on in an initial workshop, topics which should be considered in the WG. Next, these topics were framed to better understand the interaction between physical & digital infrastructure and CCAM. Then, the context in which these topics were discussed needed to be elaborated more clearly. It was decided that the focus should be on specific needs, problems or issues – which could be common to many use cases or situations – where physical and digital infrastructure could support and help create a solution. Experts were asked to detail both the issue and the possible (infrastructure) solution. This paper was created to assist and motivate (and structure) the discussion.

Then the various topics and their solutions were again grouped into more general areas where the infrastructure has a role to play. Though the final choices for these areas might not come as surprises it was essential to start with the concrete issues first. This allowed focussing the discussions, better understanding the exact nature of the issue that needed solving and how Infrastructure could be part of the solution. In a final phase this lead to the formulation of concrete recommendations on how to make progress.

All results, outputs and expert recommendations of the C-ITS Platform Working Group Physical and Digital Infrastructure have been prepared and discussed by the nominated experts representing the organisations and countries listed in "C-ITS Platform Phase II Annex I WG Participant Lists", annexed to this report.

9.4. Viewpoint landscape: Aspects found while discussing

When discussing the material collection, the following aspects became evident. For some discussions it was important to be aware from which perspective a participant is considering his or her contribution. Sharing these aspects shall help in carrying out future discussions efficiently.

9.4.1 Introduction Phases

When discussing the introduction of automated vehicles and the issues they will face, the deployment phase of C-ITS is also relevant:

- **Introduction phase**
  Few vehicles are equipped (low penetration) and only selected Use-Cases / Services are deployed. Non-equipped vehicles dominate the traffic.

- **Ramp-up phase**
  A higher number of vehicles and services are deployed. Penetration is becoming significant, implying higher than 10%. Mixed scenarios (equipped/non-equipped) are dominating. Penetration is high enough to collect representative measurements or deploy measures with impact on the traffic.

- **Consolidation phase**
  Higher penetration of participating vehicles (meaning higher than 30%) and increased

number of services available. Mixed scenarios are still relevant but uptake of Connected / Cooperative vehicles is sufficient for generating high benefits and impacts in most services.

9.4.2 Spatial scenarios

Two perspectives outline this field:

- **Route-by-route / dedicated and selected roads**
  This scenario assumes that CCAM is rolled out step-by-step on dedicated routes. For example, certain services or functions might initially become available only on some motorway stretches of a set of urban roads. Gradually the number of roads / routes will grow. It is still open whether full coverage is needed in all cases.

- **Full coverage**
  This scenario assumes that CCAM implementation covers a complete area such as a continent, a nation or at least a full city or the full road-network of a certain class.

An example for the route-by-route case could be an introduction of roads on which fully automated (driver out of loop) driving is executed. This could be achieved by deploying specific C-ITS equipment on dedicated spots only – which implies more manageable investments and procedures.

An example for the full coverage case could be agreements on minimum communication protocols or messages to be supported, legal frameworks or the European Public Key Infrastructure (PKI) for C-ITS. Work to support this has been started through the Urban ITS initiative of DG MOVE. ITS standardisation in CEN is now ongoing for METR (Management of Electronic Traffic Regulations), where most of the digital regulations will be highly relevant for CCAM.

9.4.3 Connectivity involved

- **Connected:**
  This aspect assumes that considered vehicles / functions benefit from connectivity (V2V and V2X) using short-range and cellular communication.

- **Not-Connected:**
  This aspect assumes that considered vehicles / functions work without any connection or communication.

This distinction became important when the term "autonomous" entered into discussions. Discussing "autonomous driving" in the context of C-ITS is deemed pointless as the assumption is that autonomous implies Not-Connected. Though full consensus may not yet exist on this topic, within this group this scenario (not-connected) is not considered an option. In other words an extension of the electronic horizon beyond what vehicle sensors can detect directly is deemed necessary and future vehicles (in particular automated ones) will make use of connectivity and cooperative systems.

9.4.4 Level of automation

The SAE J3016 standard distinguishes between 6 Automation levels (ranging from no to full automation). In the context of the role of infrastructure – and as illustrated in Figure 9 – the main criteria relevant for discussions is the degree of driver involvement.

- **Driver in-the-loop (L0 – L2)**
  This assumes that considered vehicles / functions are working whilst a driver remains in full control of the vehicle.

- **Driver out-of-the-loop (L4 – L5)**
  This assumes that considered vehicles / functions work whilst the driver no longer has a responsibility to survey the function. The machine is fully responsible to manage a limited and well defined situation (or any in the case of L5).

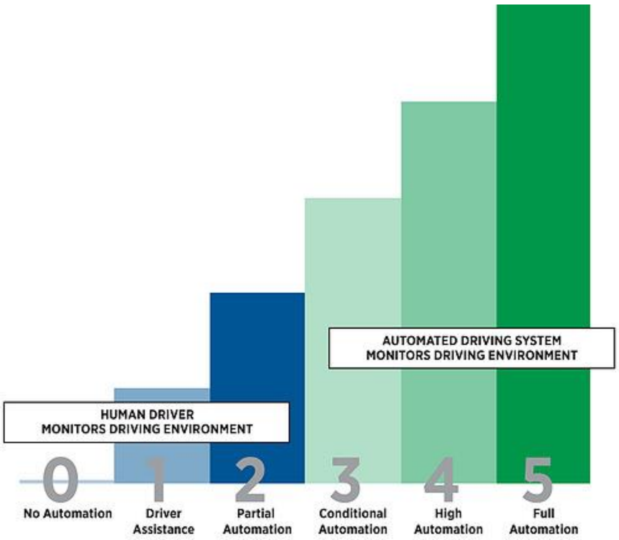

Figure 9: SAE levels of automation

As discussed later in this document the divide between driver in- and out-of-the-loop cannot be clearly drawn between L2 and L3. This is because L3 systems are responsible for monitoring the driving environment but still rely on the human driver as a back-up plan. In other words, when the L3 system encounters a situation it considers outside of its capabilities it expects being able to call upon the human driver to take back control of the vehicle, putting him of course back in-the-loop. Additionally, at this stage a lot of uncertainty exists on how fast such a transition could realistically and safely take place, and this for a wide range of human drivers, with varying experience and possibly considerable over-reliance on the L3 system.

This aspect is often mixed into "autonomous car" notions. Thus the distinction of being independent from communication and being independent from driver surveillance is clearer.

9.4.5 ITS Directive

Under the ITS directive from 2010 several delegated acts have been adopted, such as (EU) 2015/962, on the provision of EU-wide real-time traffic information services. It is important to note that real-time traffic information in the scope of this Delegated Act covers both static and dynamic data.

Setting up operational projects, addressing data exchange in support of Union-wide multimodal travel and real-time traffic information services on the TEN-T network, is the topic of an action recently launched by DG MOVE[49]. The objective is to support the implementation of delegated regulations under Directive 2010/40/EU regarding the requirements to make road, traffic and transport services data used for digital maps accurate and available to digital map producers and service providers through national access points.

Also adopted is (EU) 886/2013 on data and procedures for the provision, where possible, of road safety-related minimum universal traffic information free of charge to users. In this Delegated Act the following safety related events were recognised:

- Temporary slippery road;
- Animal, people, obstacles, debris on the road;
- Unprotected accident area;
- Short-term road works;
- Reduced visibility;
- Wrong-way driver;
- Unmanaged blockage of a road;
- Exceptional weather conditions.

In parallel in 2011 in ETSI the Basic Set of Applications, the ETSI TR 102 638 v1.1.1 (2011-06) was developed. Running projects have enhanced our view on these and today we distinguish 3 levels of safety: active, integral and passive safety such as described below.

In normal driving information is typically strategic and non-time-critical but when we go to warning and integral safety this changes quickly to becoming tactical. Passive safety comes afterwards and here information is intended for rescue facilities such as eCall. TR 102 638 is currently under revision and will at some point be updated to include services beyond Day 1, but the main findings and recommendations are not expected to change.

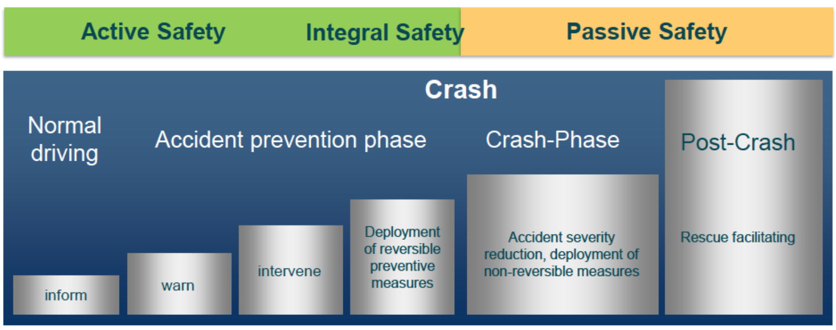

Figure 10: Phases of the vehicular safety system

[49] https://ec.europa.eu/transport/facts-fundings/grants/2017-b4-psa-its_en

Figure 10 also distinguishes between different impact phases and we can differentiate information as being strategic and tactical. Strategic information is generally about static or temporary situations. The information is informative, may include entertainment and in general has no safety impact. Strategic information from road operators or traffic management centres is usually provided to road users with the intention to influence their behaviour (e.g. change their routes) and reduce congestion. In general, the impact of this information on driving behaviour lies in a timeframe of longer than a minute or so. Tactical information is information which is relevant at short notice, almost at the time it is provided. In that case, we talk about Safety Related information.

9.5. Recommendations and Follow-Up Actions

9.5.1 Physical and digital infrastructure support for automated mobility

Exactly how physical and digital infrastructure will evolve and support CCAM is not clear at this point. This is related to the fast technological developments and the uncertainty to what is achievable – at reasonable cost – with on-board sensors and data processing. But regardless of where the future balance will lie between vehicle capabilities and infrastructure support it is well understood by all that a certain level of redundancy between the two is very welcome.

Understandably OEMs are reluctant to accept (strong) dependence on infrastructure as it adds a risk for delays in the roll-out of these technologies in a highly competitive environment. At the same time road authorities are reluctant to invest in additional infrastructure without clear indications of what is needed and what the budgetary impact will be. And though everybody agrees that the digital infrastructure – in other words data and all processes to create, update and transmit data – will play an increasingly important role, many actors are looking for the right business model to provide, share, and exploit that data, which is not necessarily seen as compatible with voluntarily sharing of data.

This however should not be seen as a limit to making significant progress, nor should a true level 5 vehicle as defined in the SAE J3016 standard necessarily be the end-goal, as there are many cases imaginable where sufficient infrastructure support will enable high levels of automation. Initially two scenarios are likely to arise:

1. **Automated Highway Driving**: this is really a relatively small – yet difficult to achieve – evolution from the most advanced driving assistance systems available today. Current state-of-the-art vehicles have numerous safety systems which, complemented by a long evolution of ever more advanced cruise control systems, now also include lateral or steering control. Main difference is that today's systems still put responsibility for driving entirely with the human driver, who thus needs to hold the wheel, monitor traffic and generally be in control, or capable of taking control, of the vehicle at all times. Switching to SAE level 3 offers essentially the same functionality but puts the vehicle in control and reduces the human to the back-up

plan. Simply put the driver can read e-mails or a newspaper but is still behind the wheel and should be able to take control of the vehicle in a reasonable timeframe. What reasonable means in this context however is still a matter of debate and research. For this very reason some vehicle manufacturers have announced to skip level 3 and go for SAE level 4 directly. Vehicles are likely still privately owned and technology is expected be introduced on premium models first.

2. **Driverless Urban Driving**: this would be a far larger break from traditional driving and could revolutionise public transport and bridge the current gap with taxis (in the sense that taxis are usually not shared). Removing the need for a driver altogether could open a route to (much) smaller vehicles (compared to collective transport) and add door-to-door capability. Passengers would not be able to take control of the vehicle (even if they wanted to) and in case of a breakdown the vehicle would either stop at the nearest safe harbour, default to limp home mode or be remote controlled by a trained operator. This seemingly far more difficult technical challenge (compared to the first use case) is made possible by restricting the vehicle not only to the urban environment – which implies limiting speed – but likely also to specific areas or streets or initially even fixed routes which offer sufficient (digital) infrastructure support. Furthermore, urban environments benefit from good communication network coverage and plentiful positioning beacons in the form of buildings. In this scenario vehicles are no longer privately owned and will never leave the urban environment. A driverless vehicle which is restricted in its operational areas corresponds to SAE level 4.

In a next phase, we can imagine both classes of vehicles expanding their capabilities as well as infrastructure support extending to ever larger portions of the transport network. In other words, Highway Driving – which might start on the main transport corridors – will expand to all highways of the TEN-T core network and next tackle the comprehensive network and all secondary roads, along the way becoming a SAE level 4 vehicle. Meanwhile urban driving will leave its fixed routes, cover entire cities and extend to its suburbs. Both will complement existing collective transport, as urban rail will cross-congested cities faster, high-speed trains will link major urban areas faster and aircraft will remain the default choice for larger distances. Most importantly, the need (and maybe desire) to privately own vehicles will largely disappear and seamless and affordable connections made possible by automated driving removes the need for true level 5 vehicles altogether. Rather, (driverless) level 4 vehicles, specialised for certain driving environments will complement each other and make door-to-door multimodal mobility a reality. Several ongoing and already planned (EU funded) pilots around Europe are working on this and will further demonstrate CCAM in both urban and interurban environments.

Recommendation 1: While vehicles will gradually become more connected and smarter in the future, it is accepted that infrastructure will continue to play a role. As detailed local infrastructure support – physical and/or digital – may never cover the entire road network (including unpaved roads etc.), there are doubts whether full level 5 scenarios will truly materialise (implying drive anywhere anytime without any human back-up plan). Therefore, it is recommended that public and private stakeholders jointly look for scenarios where infrastructure investment and deployment of automated mobility makes most sense, creating "level 4 islands" which can gradually grow and merge into larger interoperable areas in support of new (automated and driverless) mobility services.

9.5.2 Roads for automation

Partially automated vehicles, in particular those that are expected to switch on a relatively regular basis between automated and human controlled functionality have particular concerns in managing this transition. Every time such a vehicle is requested to enter automated mode, at least three parties play a role in the decision process: the driver (requesting the handover), the road authority (providing critical information to support the handover decision) and – most importantly – the vehicle (deciding, possibly supported by an OEM cloud, whether it is ready to assume responsibility for the driving task). Though ultimate responsibility for using automatic mode clearly must lie with the vehicle (and thus OEM or other approved operator) two different scenarios are considered for the role of road authorities:

1. Road authorities / operators limit or allow certain functionality in function of the available road infrastructure, traffic conditions and external factors such as visibility and other environmental factors. This is analogous to speed limits where the road authority sets a maximum limit but the driver is still responsible for choosing an adequate speed based on his assessment of the driving situation. A geo-fence for a large region could for example allow automation, but with special safety conditions. In other areas (e.g. urban environments), the top-level fence might say that automated driving is only allowed in permitted areas. It should also be noted that such limits cannot be defined for the entire road network immediately, in which case the default status, in other words "no information", should not be interpreted as "automated driving allowed" but rather the opposite.

2. Road authorities / operators provide a maximum of information available on road attributes relevant for the support of automated driving to help the vehicle decide whether enter automated driving is possible. They however play no formal role in allowing or forbidding the use of automated driving functions and expect vehicles to follow traffic rules and perform at least as well as human drivers in terms of road safety and traffic efficiency. Their ability to do so should be assessed in type approval and possibly approval of operation in the road traffic environment.

Note that these two positions are not that different, at least when “Traffic Regulations” become an integral part of the digital infrastructure. If and when new standards are complete and legally harmonized for interoperability, the two positions will likely merge.

As there is a clear interaction between the support offered by the road infrastructure and the technical capabilities or limitations of different vehicles it might not be possible (or indeed desirable) to classify roads in function of the SAE level they support. Neither is it clear at this point whether any classification in (any other type of) well-defined categories is necessary. But at the very least, key properties of road (sections) and their vital attributes for supporting automated driving need to be identified, standardised and communicated (e.g. are beacons present to complement lane marking? Are procedures in place to ensure timely updates on road works and/or are service trucks equipped with communication equipped warning on-coming traffic?). Such properties are expected to cover both static and dynamic data.

Furthermore, as information provided by Road Authorities / Operators becomes part of the vehicular Automation safety system, aspects as Quality of Services (QoS) and Functional Safety (ISO 26262) need to be considered as they may have an impact on the functional possibilities, the Infrastructure systems and possible regulatory requirements.

Recommendation 2a: Road operators to identify, in close collaboration with OEMs and digital map providers, key attributes of roads relevant for automated driving, with the aim of adding predictability on what to expect on the road ahead and enlarging the decision base for using automatic mode. Where needed, possible or desirable define values for these attributes.

Recommendation 2b: Once identified these attributes will need to be moved into formal standards in Management of Electronic Traffic Regulations (METR) and merged into road and traffic regulation for international harmonization.

Recommendation 2c: To investigate the (regulatory) consequences of Quality of Service and Functional Safety needs with respect to information sharing and the resulting infrastructure requirements.

9.5.3 Connectivity for automation

Automated driving, whether on highways, rural roads or in an urban environment, will rely on both the vehicles' on-board sensors and information from the physical and digital infrastructure. The latter implies a data transfer between vehicles and infrastructure. Though existing vehicular systems based on cameras (and other sensors) will continue to evolve and will continue playing an essential role it is no longer debated that radio communication is a far more elegant solution for exchanging information with road infrastructure and between vehicles, as it does not suffer from line-of-sight limitations. It does not require huge processing power to "understand" what is being transferred (digital cameras are better optical instruments than human eyes however computers' understanding or real-time interpretation of images is still far away from human capabilities). Computers are much faster than humans in processing information in known formats (e.g. Electronic Stability Programs, standard fit to all new cars, can evaluate wheel spin or slip on individual wheels and correct brake forces hundreds of times per second). Radio communication is thus not limited to what can be visualised on existing variable message signs made for humans.

Recommendation 3: To enable efficient data exchange between vehicles and with road, regional, local and other authorities and fully exploit the support from digital road infrastructure (for example by adding predictability through standardised road attributes in support of automated driving) ***automated vehicles shall be cooperative and connected vehicles***.

All existing connectivity recommendations from Phase I of the platform remain valid, in other words automated vehicles shall make use of a hybrid communication strategy, which includes both short-range and long-range communication technologies[50]. The hybrid communication strategy is important for the timely availability of information, which for interoperability reasons necessitates open, standard interfaces. Additionally, mechanisms need to be in place to ensure trust and in this respect a crucial milestone was met by the C-ITS platform in June 2017 with the agreement on the first version of the common certificate policy by all involved public and private actors.

This builds on the deployment of Cooperative Intelligent Transport Systems (C-ITS) and to ensure interoperability shall include at least ITS-G5 and existing cellular networks. Interoperability of services is needed geographically across Europe and potentially globally but, equally important, interoperability is also needed across generations of technologies, which requires open, standardised interfaces and consistent end-to-end security features. Though this will somewhat depend on how automation technologies will evolve automated vehicles will most likely also include newer technologies (e.g. 5G targets remote controlling of an automated vehicle, requiring communications supporting high QoS levels with redundancy and fall-back features – required for Functional Safety – to carry data such as HD video streams from the vehicle and commands from the operator, something which is not economically feasible with currently mature technologies).

Besides the many benefits from C-ITS services, which are equally useful in the context of an automated vehicle, connectivity is arguably even more important for automated vehicles. This follows from the fact some automation services will simply not work without connectivity (e.g. platooning) or at the very least not as smoothly or efficiently (e.g.

[50] See COM(2016)766: a European Strategy on C-ITS

emergency braking). Even when the vehicles sensors detect the danger in time to react the vehicle might be forced to (automatically) brake so hard as to create a dangerous situation for following traffic (e.g. a human driver lacking the reaction times of the automated one). And even when all vehicles would become automated and all human limitations would be removed, vehicles would still benefit from connectivity to be better aware of their surroundings, coordinate their actions and provide a much smoother driving experience for their passengers, whilst at the same time increasing capacity and efficiency as such coordination would allow vehicles to align their relative speeds and safely drive much closer than otherwise possible.

9.5.4 Position support

All automated road vehicles will need increasingly accurate, timely and reliable positioning. Additionally, as CCAM will move to higher SAE levels, the need for redundancy in position support will arise. In other words, when the driver will be no longer in control nor be the fall-back solution, the vehicle requirements for multiple fail safe systems will increase.

Most use cases need positioning accuracy down to lane level, meaning consistently reliable positioning below one meter. For some critical manoeuvres accuracy may be needed down to decimetre level and European projects such as HIGHTS[51] show that the reliable detection of a Vulnerable Road User (VRU) or a motorcycle driving between two vehicles requires geolocation accuracy of less than 30 cm.

Multi-constellation Global Navigation Satellite System (GNSS) would bring higher satellite availability and redundancy, which would also increase position accuracy, but to realize such accuracies and availabilities GNSS alone is not sufficient. Further improvement is already possible today if information from complementing technologies could be shared, which again requires communication between vehicles and between vehicles and infrastructure.

Currently the following possibilities have been recognized.

- The provisioning by the infrastructure of Real Time Kinematic (RTK) information via Hybrid Communications to Vehicles and other road users.
- As the infrastructure is static and knows the local satellite constellation, it can provide selective parts of the raw satellite data to road users, effectively providing them with data from satellites they cannot see.
- By combining CAM information with radio analyses of the signals received from other road users, requiring no contribution from infrastructure.

[51] http://hights.eu/

- By providing MAP (road topology) information including highly accurate geolocation referencing information of MAP specific elements such as the stop line.

- By providing highly accurate geolocation of known objects or landmarks along the road. Long-term static elements can be included in the HD-MAP whilst short-term dynamic/static elements could communicate locally using short-range communication. This could include the sharing of the location of non-equipped road users such as pedestrians by the Infrastructure. Condition: the object or landmark should have an easily visible and accurate reference point as otherwise the improvement will be limited. In an Urban environment buildings and other static objects could likely provide such reference points, the extra urban environment will likely require additional infrastructure support to create reference points.

Recommendation 4a: Road operators, OEMs and suppliers should jointly investigate how physical and digital infrastructure can contribute to redundancy and safety in accurate positioning. This includes investigating the needs for landmarks along the roads considered for higher level automated driving, and to consider providing them where socio-economically feasible, in particular for temporary work zones and higher risk road sections (e.g. tunnels, urban canyons).

Recommendation 4b: To stimulate the standardisation of the information exchange required for these improvements and support the implementation of interoperable European Geolocation Referencing services.

9.5.5 Handling complex traffic situations / Intersections

There are numerous complex situations, in which information sharing and cooperation can be a huge benefit, but only when we manage to clearly define and standardise how we will describe these situations and intersections. For example, such situations may be road works or construction zones, complex lane merging, knowing if and where emergency vehicles are circulating in the network and how they should be supported, any situations on intersections including the current (and future) signalling, any priority actions at the intersection, detection of vulnerable road users or police officers controlling traffic flows. Currently, all but the last two use cases are already partly standardised as far as message content delivered to the vehicle is concerned.

In all these cases, there is a clear interest to provide highly automated systems with as much information as possible to increase their understanding of the situation and prevent risk prone behaviour. This implies also a common understanding of the definition and operation of the functions or services used either to create or to re-use that information, and the reliability and timeliness of the information. In other words, we need a common environment for sharing perception data.

The creation of an environment in which all perception data can be shared will be particularly useful to accelerate the benefits in terms of road safety and traffic efficiency when uptake rates of cooperative systems are still modest. This is because a future (automated) vehicle will perceive its surroundings through different sensors, receive other information from nearby C-ITS equipped vehicles, and thus be aware of where they are even when he cannot see them. The new requirement is the need to also hear and see what all other C-ITS equipped vehicles hear and see, something which initially will include a large portion of non-C-ITS equipped vehicles. In other words, we move from individual to collective perception, or I see what we see collectively.

Realising an operational environment for sharing perception data will require amongst others, the full description of complex situations and its subsequent break-down into more simple elements. This may also require that context information is added to the functional information already being shared by C-ITS, possibly including elements such as who generated the information, based on what situation or system, what timelines etc. The impact on privacy and data protection of how this information is subsequently used in various use cases needs to be reviewed. And as always pan-European interoperability will need to be ensured through detailed profiling work, as is currently ongoing for mature services in the C-ROADS platform.

A start of the development of collective perception is currently been standardized by ETSI in the ETSI report TR 103 562 “Informative report for the Collective Perception Service” and the Collective Perception Message (CPM) service TS 103 324. This type of information exchange may be even more beneficial for lower automation levels where humans are in control, and so the deployment should be encouraged as soon as possible.

Recommendation 5a: To support handling complex traffic situations, vehicle industry, road operators, supplier industry and academia need to work together to define common operational environments for collective perception. Based on those results a new set of technology agnostic C-ITS messages for collective perception needs to be standardised.

The received core information is however not particularly useful on its own. Can I trust this info? Was the entity sending it allowed to send it? Has it been manipulated? Is the data precise and accurate enough for my purposes? Is the data valid for where I am? Has the data expired or is it still relevant?

Another distinguishing characteristic of the received information is whether it is regulatory information or whether it is sensor data. Traffic lights are a good example to illustrate the difference between these two information types.

1. The traffic code says that you shall stop on red
2. The sensor or SPAT message says that it is now red

3. The automation behaviour rules based on this information will decide to stop

So far there has been a large focus on the second part where data from the surroundings has been defined. The ground rules for correct behaviour and the right actions when receiving and/or sensing these situations has been taken for granted. This view is obviously too limited. In reality the behaviour rules codified in traffic codes vary quite a bit depending on the country/region, and it also changes with time. The example of traffic lights is one with little variability. Parking regulations with its numerous sub-regulations are often much more time and place variant, but equally important to follow. Sometimes traffic codes can change quite dramatically, for example when Sweden switched driving side in 1967. Point is that traffic behaviour is a government regulation and it is not the same everywhere or at all times, and therefore these rules also have to be conveyed to the automated vehicle. This work has started in CEN under the METR umbrella but requires involvement from all actors.

Recommendation 5b: all actors (OEMs, suppliers, authorities) must work together to create standardised C-ITS messages for traffic regulations, complementing existing "sensor-type" C-ITS messages, both of which are needed for the vehicle to take the correct action.

Standards for collective perception, covering the information content and traffic regulations are in isolation still not enough. There is an obvious need to quantify trustworthiness, precision, timeliness and reliability of information. This needs to go hand in hand with the evolution of core technical standards, so that information also carries the relevant metadata to provide context and create trust.

Recommendation 5c: Specific standards on the context and the interpretation boundaries at receiving side (including the quality assumptions to quantify trustworthiness, precision, timeliness and reliability of information) need to be developed and implemented in all C-ITS equipment.

At the same time, and in parallel to the many development and standardisation tasks described above, we need to think about a framework for collective perception. We need to identify all the different stakeholders and all essential elements and regulatory requirements needed to make it work. We need to define the responsibilities of all involved and the supporting tools required to make it happen.

9.5.6 Consistency between physical and digital

Physical infrastructure will increasingly be complemented by digital infrastructure, and may over time – at least partially – be replaced by it. In some cases, the lack of physical infrastructure (e.g. lane markings in toll plazas) can be resolved by virtual/digital lane markings, guiding automated vehicles. To avoid confusing and potentially dangerous situations consistency in the information coming from the physical and digital infrastructure is however vital, imagine for example a significant difference in speed limits communicated by the physical and digital infrastructure respectively.

To build the digital infrastructure and maintain a high level of consistency between the information coming from the physical and digital infrastructure, increased collaboration between all public and private actors that possess, control or own data is required.

This means that infrastructure operators need to become increasingly aware of their role in creating and maintaining the digital infrastructure, including the mechanisms on public side to provide data needed for updating the digital infrastructure. At the same time public authorities could benefit greatly from data generated and shared by vehicles. To unlock the large potential of such vehicle sensory data however, the right balance between privacy regulation and the societal benefit of data sharing needs to be found.

Private parties on the other hand would benefit greatly from more accurate and timely data from the public side but need the right framework to share data – with public and private stakeholders – whilst protecting legitimate commercial interests. For some types of data there is existing legislation, notably under the ITS Directive, creating a framework for and in some case an obligation to share data.

Recommendation 6: All actors that possess, control or own data need to work on the accelerated and joint implementation – by public and private stakeholders – of existing and future Delegated Acts under the ITS directive. All actors are encouraged to jointly define fair conditions for sharing data, taking into account the costs related to transforming raw data into useful (traffic) information.

9.5.7 Legal aspects of digital infrastructure

So far only the technical aspects have been covered. The realization that electronic traffic regulations forms an integral part of digital infrastructure introduces some new regulatory challenges, and not the least many new implementation and operational challenges. On a national level, who gets to set traffic regulations? Will they be regional or city authorities? Which department inside the cities? How do we codify the new electronic regulations into national regulations with legal certainty? What happens when the road sign says something different than the electronic signs?

These and many other questions will need to be answered at the national level and need discussion on the European level to investigate the required and possible level of harmonization.

Recommendation 7: Similar to vehicles, also infrastructure will continue to evolve by introducing new technologies, generating new data and new information flows. A clear legal framework – including traffic regulation – will be essential to avoid (new) conflicts between information coming from physical and digital infrastructure, and establish precedence regarding information.

10. Working Group - Enhanced Traffic Management

10.1. Introduction

Convergence between cooperative, connected and automated systems is expected to bring several benefits in terms of road safety, traffic flow efficiency and emission reduction. Together with digitalisation and the development of new mobility services, the road transport sector can positively evolve into a more intelligent and sustainable era.

Throughout the working group's discussion phase, the positive outlook for the development of cooperative, connected and automated systems was often reinforced with encouraging results from several projects and studies, showing that, e.g.:

- Data collected in Field Operational Tests on the use of In-Vehicle Signage, when combining *dynamic speed limits* and *intelligent speed assistance*, was shown to have a dramatic impact on road safety, potentially more than halving the number of accidents[52].
- Traffic simulations of *Cooperative Lane Changing*[53], in which slight reductions of speed are combined with an increased safety distance in between vehicles, showed significant improvement in traffic flow efficiency. Congestion on motorways, due to lane closure, could practically be avoided with only a 20% penetration rate of connected and cooperative vehicles in mixed traffic conditions.

However, before concepts such as *proactive management of traffic demand* or *accident and congestion avoidance* and *congestion dissipation* can become a reality, it is important to understand that the period in which mixed fleets of vehicles (full, semi and non-automated) will coexist on our roads will be long.

It's also important to acknowledge that, after 2019, connected and automated vehicles will permeate our daily lives, more and more. This transition period of mixed traffic conditions, will have an impact on traffic managers and their systems.

Therefore, while aiming for that long-term vision, the C-ITS Platform Working Group on *Enhanced Traffic Management* aimed to understand what the immediate steps were and how incremental levels of connectivity and automation could improve traffic flow efficiency and enable optimal network operations.

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[52] Project Drive-C2X - http://www.drive-c2x.eu/project

[53] With reference to 'Cooperative incident management' developed under the C-ITS Research activities at Trinity College Dublin, Ireland.

This meant to identify and develop the right set of tools to deploy Pan-European *Cooperative Traffic Management Services*, while ensuring their interoperability across borders, cities and brands.

10.2. Definitions

While framing the scope of the Working Group, several definitions were taken into account. The general definitions relate to road safety information and a particular sub set of real time traffic information, linked directly with traffic management procedures. They comply with the ITS Directive and its Delegated Regulations.

The discussion phase provided an opportunity to, sometimes, think outside the box. The most significant new concepts are explained upfront, in order for the reader to better apprehend them.

10.2.1 General definitions

The following definitions apply, in accordance to *Delegated Regulation (EU) No 886/2013 on 15 May 2013, addressing data and procedures for the provision, where possible, of road safety-related minimum universal traffic information free of charge to users* and *Delegated Regulation (EU) No 962/2015 on 18 December 2014 addressing the provision of EU-wide real-time traffic information services*,

- ***Accident, incident and event***
- ***Road safety-related traffic data***
- ***Traffic data***
- ***Real-time traffic information***
- ***Real-time traffic information service***
- ***Temporary traffic management measures***
- ***Traffic circulation plans***
- ***Access point***
- **Traffic management**[54] provides guidance to the European traveller and haulier on the condition of the road network. It detects incidents and emergencies, implements response strategies to ensure safe and efficient use of the road network and optimises the existing infrastructure, including across borders. Incidents can be unforeseeable or planned: accidents, road works, adverse weather conditions, strikes, demonstrations, major public events, holiday traffic peaks or other capacity overload.

[54] https://ec.europa.eu/transport/themes/its/road/application_areas/traffic_management_en

10.2.2 New concepts

- **'Data Exchange'**- Data exchange allows data to be shared.
- **'Data Transaction'** - Data shared with the purpose of meeting a specific need or triggering action.
- **'Traffic Management related data'** means dynamic road status data and traffic data that is relevant for enhancing Traffic management information and services;
- **'Cooperative Incident management'** – The combination of actions from different stakeholders, needed after an incident, to put in place pre-established local and regional measures, in order to restore safe and flow efficient conditions.
- **'Cooperative Traffic management'** - A Connected, decentralized, traffic management system in which all stakeholders can act collaboratively, either to provide individually, high quality, profiled services or to preserve the collective's best interest, as for safety, flow efficiency and emission reduction.
- **'Service value chain'** corresponds to the value proposition of a service, provided by combination of different actors.
- **'Smart Governance'** is to be understood as the common agreements, set between different stakeholders, allowing them communicate, collaborate and perform together, while exchanging/transacting *traffic management related data*.
- **'Orchestration of services'** – means to put in place, when appropriate, the traffic management measures by the means of the different stakeholders, public and private, that are required to come together and act accordingly to pre-established agreements.
- **'Orchestra conductor' –** the authority role required to bind the actors together, for the 'orchestration of the services' to take place.
- **'Decentralized applications'** – Cross brand, cooperative incident management applications, supported by adequate V2V and V2I communications that can improve safety and flow efficiency by taking action, locally, without the need of intervention of the Traffic Manager.
- **'Co-opetition'** – Co-opetition takes place when organizations that are in the same market work together in the exploration of knowledge and research of new products, at the same time that they compete for market-share of their products and in the exploitation of the knowledge created. Co-opetition helps them to reach a higher value creation, when compared to the value created without interaction.

10.3. Executive summary

Beside the preparation of a stakeholder roadmap on vehicle automation within GEAR 2030, the second phase of the C-ITS Platform posed an opportunity to think on how to take advantage of cooperative, connected and automated systems to enhance traffic management's efficiency.

The discussions showed a gap of technical tools for promoting the appropriate interaction between the *vehicle* and the *road*.

C-ITS equipped and automated vehicles will soon hit the roads. These vehicles will be 'connected computers on wheels'. In order for them to act and comply accordingly, traffic regulations (static or dynamic; mandatory or advised) need to be digitalised and become 'electronic regulations', able to be coded into the vehicles. The development of advanced automated driving functions depends upon them.

To better manage traffic, the Road manager needs to be able to translate its mobility policy into a *digitalised standardised language*, so that it can be exchanged with the other road sector stakeholders.

The Working Group focused on identifying the most appropriate use cases to address the governance and operational aspects in which the mutual recognition of benefits - *win-win situations* - would be most commonly perceived, in order to promote cooperation among public and private stakeholders.

The split between the governance and the management levels was important to establish, because the definition of the mobility policy precedes its operational implementation.

Deploying circulation or traffic management plans, along major corridors or urban networks provided the perfect background to realise the potential of cooperative, connected and automated mobility and to understand the impacts on the roles and borders of the Road Authorities, Traffic managers, the Service providers, the Vehicle manufactures and the physical and digital Infrastructure stakeholders.

Establishing the vision for the Working Group[55] – *Cooperative Traffic Management* - helped to identify the basic requirements to unlock cooperation:

- **Communication** – for the purposes of awareness or compliance, the exchange of the appropriate *traffic management related data*, will be bi-directional.
- **Performance** – traffic flow conditions will be commonly understood and assessed.

[55] The WG followed a simplified strategic approach based on the *Balanced Scorecard*, available in *EnTM Annex II - The Strategic approach*

- **Collaboration** – the actions, from both the public and private sectors, will be complementary, decentralized, and put in place according to pre-arranged agreements.

Cooperative Traffic Management Services will need to be well orchestrated, as they depend on combined efforts from those involved in the service value-chain, both from the public or private sector.

To avoid market fragmentation and promote the Pan-European rollout of the *Cooperative traffic management services*, the Working Group considered the need for scalable and replicable tools to be used across the entire European road network.

These tools should provide enough flexibility for city authorities, regardless of their size or mobility policy, and also for traffic managers and road operators, to deploy the services under every possible scenario.

To help Public authorities play the role of the *orchestra conductor* and translate their mobility plans into 'standardized exchangeable data', the Working Group conceptualized a specific set of important tools that need to be developed:

- The 4 Building blocks for digital Traffic Management Plans[56].

    1. The first building block consists on a *classification of roads* to be done accordingly to network flow hierarchy; Not always the shortest path will be fastest, nor the safest. This tool will help public authorities and road managers to conveniently present their views of the main road network hierarchy and the preferred alternatives. These may be useful for re-routing traffic over an area that is becoming saturated, using Green light optimized speed advisory (GLOSA), or for tailoring profiles, targeted to specific road user groups, e.g. freight, electric vehicles or passenger transport.

    2. The second building block is a *geo-fencing mechanism*, based on the day 1.5 service 'Zone access control for urban areas'. This will specially help cities to translate their zoning urban planning into *traffic management related data*, preventing routing through residential areas or close to hospitals and schools. Service Providers can relate to these zones and apply *virtual delays* on top, so that the routing algorithm proposes an alternative way, more in line with the public's authority expectations.

    3. In order to manage traffic, its flow efficiency needs to be monitored and assessed. Establishing a *network performance Level of Service* (LoS) is therefore the third required building block. LoS will depend of the road

[56] This concept is developed under Section 10.6.5.

classification or type of incident, but it will be assessed under a combination of two more evident key performance indicators; Speed and Volume. These may be collected by roadside units, loops, e.g. or provided, by specific Probe Vehicle Data.

4. The fourth and last building block is the *trigger* and it is the point in which the acknowledgment of data turns into action. After this point, the need to engage a Cooperative Traffic Management Service becomes decisive, to restore adequate safe and flow efficient traffic conditions. The triggering conditions need to be commonly agreed upon, as *Cooperative Traffic management services* are the result of a combination of orchestrated actions, from specific actors.

Finally, in order to make the orchestration of *Cooperative Traffic Management Services* possible, there is a need to develop a *Common Operational Picture*[57] (COP) to provide the involved actors with a standard overview and regional context of a traffic situation. The COP will provide a visual interface, on top of a map, enabling the display of the appropriate *traffic management related data*, in accordance with the described building blocks layers. The COP can play a major role for re-routing services, for identifying the need of any additional measures or, for facilitating extra traffic on alternative routes, etc..

This report reflects the nature and the outcomes of the discussions, held between June 2016 and July 2017, during which the working group members, while representing their own interests, shared views on how to achieve the Work Programme's objectives.

At the end of this period, the WG Members unanimously recommended this work to continue, beyond the second phase of the C-ITS Platform, under the European's Commission coordination.

10.4. Objectives of the Working Group

The Working Group was dedicated to understanding how to enhance Traffic Management Services, making use of connectivity and automation, while balancing between the individual's needs and the collective's best interest, to improve road safety, flow efficiency and emission reduction.

In the future, the data collected with cooperative, connected and automated systems will grow in volume, thus improving the quality of the navigation services. These services will have a big influence on traffic behaviour. However in order for the development of

[57] This concept is developed under Section 10.6.4.

cooperative, connected and automated systems, to produce the expected collective benefits, in terms of road safety and traffic flow efficiency, some alignment with the public sector is required. The work plan aimed to establish a more jointly cooperative framework, between public and private actors, looking into synergies and win-win situations.

Therefore, the automation's expected impact on the roles of the road sector stakeholders, presented the background opportunity to build upon the C-ITS day 1 and 1,5 services and map the existing projects, initiatives and technologies, while discussing the implementation options and the gaps to fill, leading to the identification of the 'Cooperative traffic management' basic operational requirements.

10.5. Organisation of Work

The WG held 11 meetings, once a month, between June 2016 and July 2017. Some of the more technical and operational contents were developed with the volunteer help of some members and the work coordinated over several teleconferences. DG MOVE chaired the work and ensured the overall logistics, meeting minutes and the drafting of the agendas.

Meetings were divided in two parts: The first part was held for consolidation purposes, as some of the attendees differed from month to month and some of the discussion on the topics needed to be reopened and further addressed. The second part started with one or two presentations of selected and relevant topics.

The regular presence of the TM 2.0 ERTICO Platform and its Task Forces[58] Leaders continuously fed the background discussions with new dimensions and contributed to the content, helping the WG to move forward.

Along this period, DG MOVE followed a simplified standardised strategic methodology approach – *Balanced Scorecard* - in order for the WG to build a common vision and a road map.

The Enhanced Traffic Management WG and the Urban WG worked closely together.

All results, outputs and expert recommendations of the C-ITS Platform Working Group EnTM have been prepared and discussed by the nominated experts representing the organisations and countries listed in "C-ITS Platform Phase II Annex I WG Participant Lists", annexed to this report.

10.6. Enhancing Traffic Management

Penetration rate increase of new vehicles equipped with cooperative, connected and automated systems is expected to be slow. After 2019, the road sector will face a long period of mixed traffic conditions.

[58]The Reports of the several Task Forces may be seen here: http://tm20.org/final-reports-on-task-forces/

Ensuring interoperable services, across borders and brands will require the *road* and the *vehicle* to come closer together to realise the expected benefits on road safety and traffic flow efficiency.

Collaboration amongst the road sector stakeholders is key.

The added value of collaboration is clear. From the *road's* perspective, Traffic Managers can expect a higher compliance with the traffic measures they issue, as connected and automated vehicles will certainly follow them to a higher degree than non-connected vehicles. From the *vehicle's* perspective, manufactures and service providers aim to achieve a better understanding of those traffic measures, in order to promote improved and more resilient mobility services.

The Working Group addressed the opportunity to discuss how the dialogue between all the involved stakeholders could be established. Three key topics were identified:

1. The **data** categories and the exchange requirements for establishing the dialogue;
2. The **governance** model in which the dialogue can be established*;*
3. The **means** for establishing the dialogue.

Regarding the *data* categories, the starting point was the list of C-ITS day 1 and 1.5 services, from which the group selected those considered as the most relevant, for the purposes of developing *Cooperative Traffic Management Services*.

Level	C-ITS Service
Day 1	In-vehicle signage
Day 1	In-vehicle speed limits
Day 1	Probe Vehicle Data
Day 1.5	Traffic information and smart routing
Day 1.5	Zone access control for urban areas[59]

The use of In-Vehicle Signage was proposed to be combined with In-vehicle speed limits, as it bundles together both aspects of *dynamic* and *static* regulation.

The *governance* model and the *means* for establishing the dialogue will be further developed from sections 10.6.2 to 10.6.5.

10.6.1 Requirements

In order to understand how to use connectivity and automation at the operational level while balancing between the individual's needs and the collective's best interest, the group

[59] The service is not listed in the official list of day 1 and 1.5 services of the C-ITS Platform, still the Working Group decided to have its reference.

decided to approach the enhancement of Traffic Management Services by establishing practical *scenarios.*

The *scenarios* provided a better view on the changes required to take place to establish the new operational processes, to identify 'who' is doing 'what' and 'how' information is conveyed across the different stakeholders, therefore, identifying any technical issues and cooperation bottlenecks to be tackled. This *scenario based approach* basically addressed:

- Real life planned and unplanned events;
- The use of day 1 and 1.5 services as inputs to the Traffic Management System;
- Regional and local measures;
- Different views of the involved stakeholders;
- Traffic regulation, static or dynamic, and routing advice.

The approach helped to draw some conclusions and develop the basic operational requirements for deploying Pan European *Cooperative Traffic Management Services*:

1. Cooperative, connected and automated systems are expected to operate in any geographical context and adapt to the requirements of different types of road networks.

- ***Requirement:*** to ensure continuity and interoperability, the *Cooperative Traffic Management Services* will not be limited to any borders.

2. The most harmonised traffic management procedures take place in the motorway network, across borders, along the comprehensive TEN-T Corridors.

- ***Requirement:*** the tools to develop the *Cooperative Traffic Management Services* will take stock of the TEN-T ITS Policy, its Regulations and the outcomes of the CEF ITS Corridors and the deployment of the C-ITS Pilots of C-Roads.

3. Traffic management procedures can differ from small-medium sized cities to major urban nodes. They can even differ between two similar cities in the same country, depending of the city's strategic mobility.
4. The complexity to operate and maintain ITS applications has implications on budget and resources. When implementing new services or migrating into new areas, cities find it hard to mix and match between different technologies, because of legacy and vendor lock-in issues.

- ***Requirement:*** to ensure flexibility, the tools to develop the *Cooperative Traffic Management Services* shall be modular, scalable, replicable and compliant with standards.

5. Definition of common data, tools and services to be available across every city in Europe, can help accomplish a homogeneous playing field across Europe.

6. Establishing common implementations, between public and private stakeholders, can scale up the market, avoid fragmentation and contribute to speed up the uptake of the benefits of connected and automated vehicles into traffic management.

- ***Requirement:*** the tools to develop the *Cooperative Traffic Management Services* shall promote joint cooperation.

7. Enhancing traffic management depends on the way the relevant data is handled and handed over along the stakeholder value chain. Governance and organizational issues in order for all the stakeholders to come together and understand each other need to be addressed.
8. The same stakeholder, public or private, can act as a producer of data as well as a consumer of data, embodying different roles along the value chain of *Cooperative Traffic Management Services*.
9. The data shall have a (minimum) level of quality. The quality requirements shall follow the quality framework developed and maintained by the EU EIP project. These quality requirements shall address geographical coverage, availability, timeliness, latency, e.g.

- ***Requirement:*** the *traffic management related data* shall meet the requirements of the different stakeholders.

10. The provision of traffic measures can either take the shape of a recommendation or an obligation. The fastest route, to a designated destination proposed by a nomadic device[60], is only an advice. A temporary lower speed limit, displayed on a variable message signal on a motorway, is mandatory to comply with.

- ***Requirement:*** Traffic measures can be provided and conveyed, either by public bodies or private organizations, but only the public sector has the authority to issue mandatory traffic measures.

10.6.2 Binding principles

By acknowledging that improving road safety and traffic flow efficiency, strongly depends on the cooperative component of Connected and Automated Mobility, the group proposed to discuss how to strengthen and intensify Cooperation.

Before being able to move forward the group needed to agree on common vision.

[60] Nomadic devices encompass both in-dash Personal Navigation Devices and Mobile Phones.

The vision should foster public and private cooperation and take into account their different interests and responsibilities. Proposing to use a Balanced Scorecard[61] methodology, for establishing a common vision and strategy, the group was invited to think of itself as an organization or community. As such, the group was asked to reflect on how it could improve its *internal processes* as well as to identify how to *learn and grow*, through research or piloting new ideas and concepts.

The exercise produced both the common agreed vision for the WG – Cooperative Traffic Management – as well as the definition of its 1st stage objectives.

Long term Vision - Cooperative Traffic Management

A Connected traffic system in which all elements act collaboratively, providing the best achievable balance between the individual's needs and the collective's best interest, as for safety, flow efficiency and emission reduction.

1st Stage Objectives

Enhancing Road Traffic Management capabilities, looking into opportunities to improve network performance, while making use of connectivity and automation to improve the full extension of the 'end to end' road user experience.

The exercise also showed that fostering Public and Private Cooperation meant to:

- Step up from a voluntary, ad-hoc, collaboration processes to a binding agreement between the different players providing a Traffic management service;
- Move from bi-lateral to multi-lateral arrangements with all relevant stakeholders to build mutual benefits for providing traffic management services.
- Evolve from open-integration to a rational of orchestrations of services, in which every player knows his role and works together;

[61] https://en.wikipedia.org/wiki/Balanced_scorecard. The exercise of using this methodology and the accomplished results is described in *EnTM Annex II: The Strategic approach*

The group agreed of three Strategic Lines to take:

'end to end' Communication

To ensure that needed Traffic Management measures are available and disseminated in real-time, trough dynamic dialogue between all the involved actors, so that mixed traffic may be aware and comply with those measures.

'end to end' Collaboration

To promote the right combination of efforts from all, either from the public or private sectors, acting as 'cooperative components' to provide safe and efficient traffic management services.

'end to end' Performance

To ensure the proper use of Public and Private resources or competences in order to provide the best achieveble quality for the provision of, either, collective binding information or individual recommendations and advice.

10.6.3 Operationalization of Cooperative Traffic Management

To illustrate and investigate what Cooperative Traffic Management means, as compared to Traffic management as it takes place now, the group discussed how Cooperative Incident Management could take place in the future. This approach made use of all the concepts presented and aimed to understand, from an operational viewpoint, how to:

- Establish new processes, in which organisations interact;
- Address the needs of Data exchange and digitalisation;
- Make cooperation more binding by taking up the shape of an agreement or a contract.

Focusing on the task to design a scenario for Cooperative Incident Management, a three-step approach was proposed to compare the current Incident Management process with the future enhanced requirements for Cooperative Incident Management (CoIM) process.

1. Detection of an incident, using current and future sensors (loops, floating vehicle data)
2. Creation of an Common Operational Picture[62]
3. Implementations of Local and Regional traffic management measures.

- **Local measures** can help to change lane or adjust speed, improving safety and flow efficiency, using appropriate V2V and V2I communications. Local measures can be carried out by the road manager/inspector or local warnings (using V2V or V2I).

[62] This concept is developed under Section 10.6.4.

- **Regional measures** relate to the tactical operational instruments to put into place, such as Traffic Management Plans. Depending of the scenario, the Regional measures can be understood as a recommendation or an obligation. Regional measures can include re-routing and/or actions to facilitate extra traffic on alternative routes.

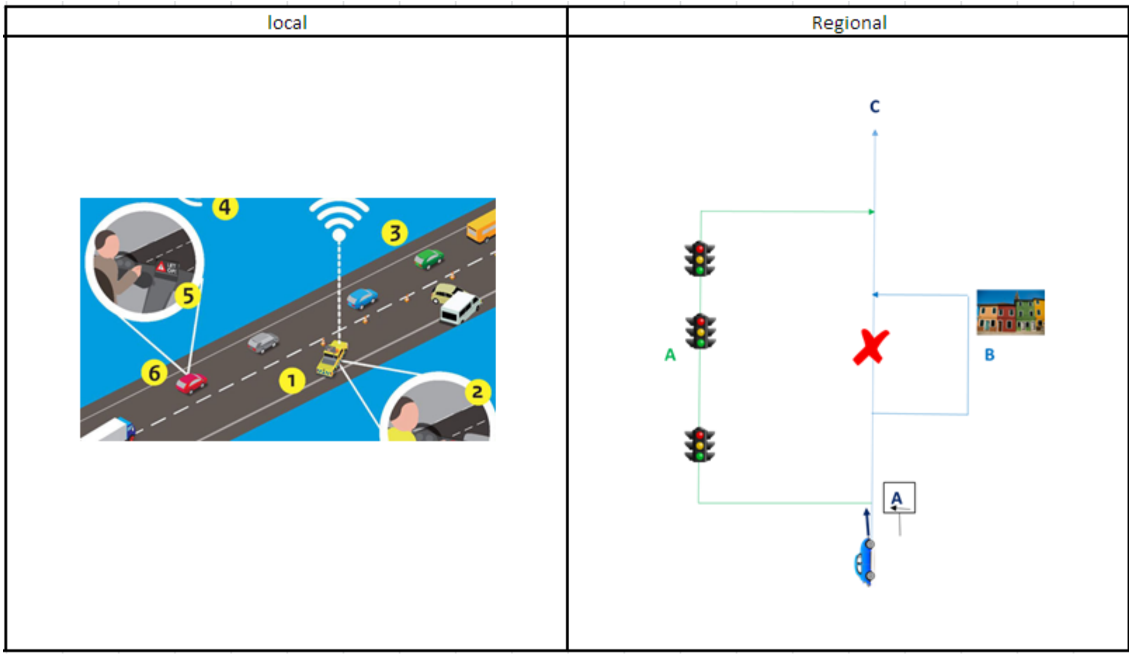

Figure 11: Scenario approach for Cooperative Traffic Management Services.

Local measures are immediate and safety-oriented, to avoid accidents through road authorities closing lanes and, in the future, providing this information directly to vehicles (I2V), as well as vehicles communicating amongst each other about manoeuvring to avoid secondary accidents. These (V2V) local measures can act as decentralised applications and improve safety and flow efficiency without the direct intervention of the Traffic Manager.

The example shown, focusses on the recurrent situation of re-routing, which requires cooperation, as demonstrated in Figure 11. Figure 12 shows two alternative routes, A and B, after an incident has been detected. Route A, although longer and maybe taking more time, is the recommended path by the public authorities. Route A can be given a green wave (thereby shortening the total travel time). Route B takes drivers thorough a residential area in the city centre with streets ill equipped to handle dense traffic. Route B is shorter and takes less time (at this point).

Unaware of these disadvantages, the private service providers recommend Route B, simply because it is shorter and fastest, therefore in line with their costumer's expectations. However, the advice ignores that Route B is inadequate to handle the extra traffic, resulting in negative local consequences. Route B will ultimately take longer, if all drivers were to be provided with that advice.

This scenario provides an opportunity for a win-win situation for Road operators and service providers as well as road users, should Road Operators and service providers come together to cooperate.

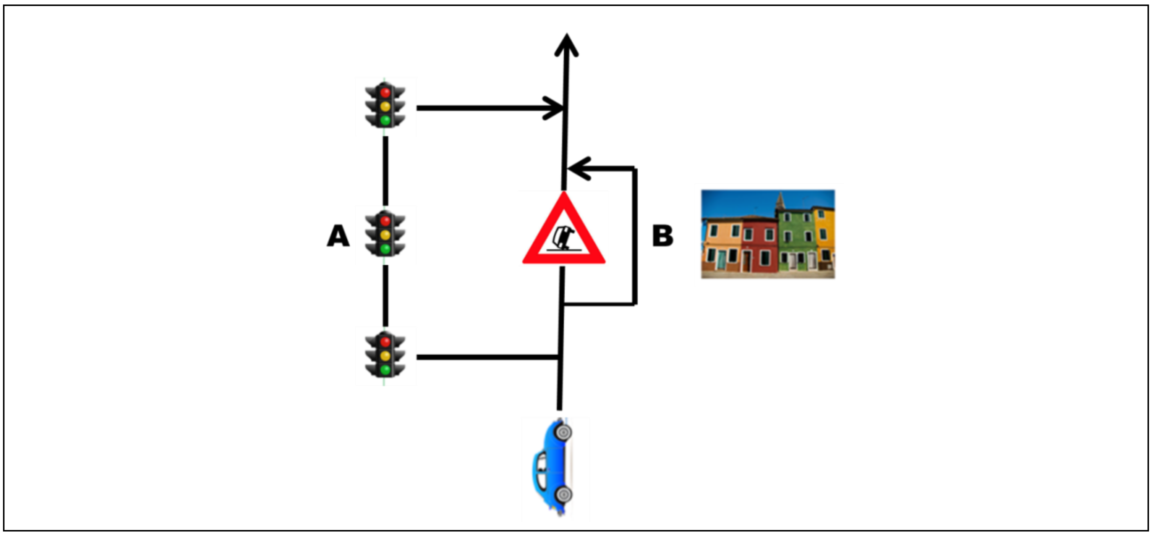

Figure 12: Regional measure: re-routing

In the ideal situation the Road operator and the service providers coordinate their activities to achieve an overall higher network performance with increased safety and reduced congestion time. Cooperation is shown in Figure 13.

The Road Operator has already agreed to create the green wave on route A, reducing travel time. The Service Provider advises its users to also take Route A in this case, and does so by introducing a penalty (virtual delay) in its shortest route algorithms on route B.

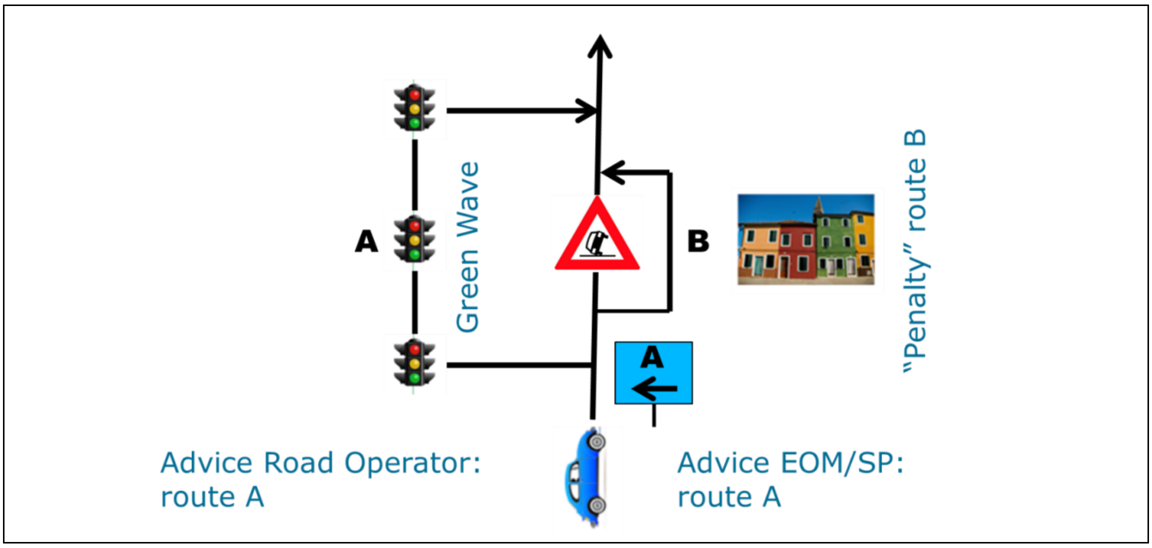

Figure 13: Future re-routing

In another case, there may be several alternative routes that road users can take. In this case, Service Providers can balance their route advice using a Smart Routing algorithm. Figure 14 shows a case in which 60% of the road users are advised to take the purple route and 40% the green route, to have roughly equal travel times on the routes, lowering overall congestion.

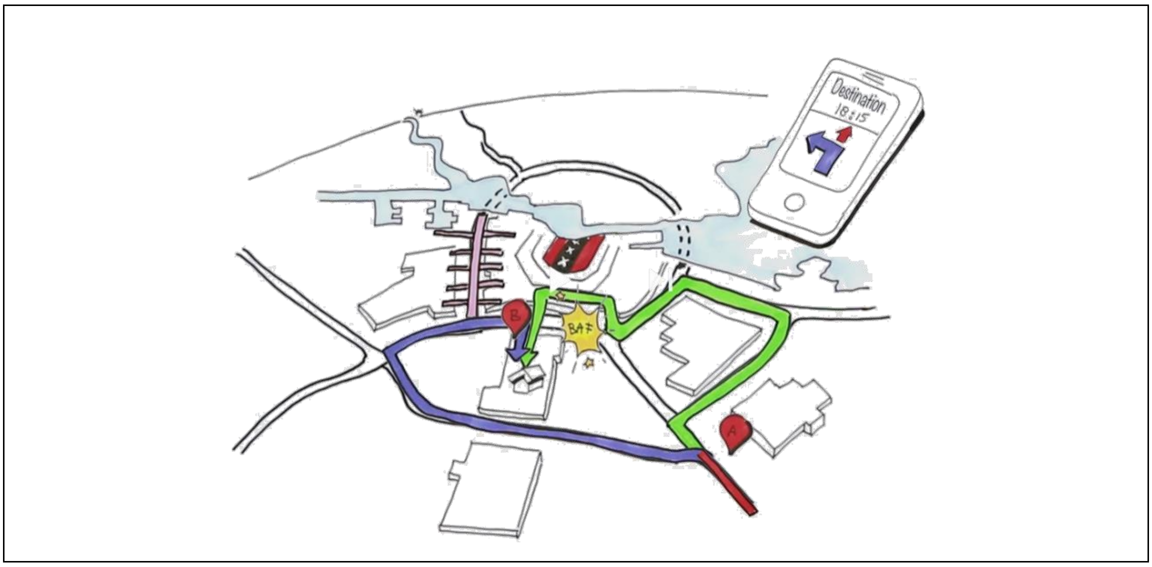

Figure 14: Smart Routing

This example clearly shows the need for the public and private sectors to develop the adequate tools, in order to better interact and improve consistency of recommendations. It also points out, how the use of C-ITS and Cooperative, connected and automated systems could improve flow efficiency, as these systems are expected to better comply with such recommendations.

10.6.4 The Common Operational Picture

A Common Operational Picture (COP), a term widely used in the military domain to support situational awareness but often refereed within incident and event management activities, should be jointly developed and implemented by all public and private actors, in order to support the required collaborative approach and efficient combination of efforts, towards safe and efficient delivery of traffic management services.

At the operational level, setting up *Cooperative Traffic Management Services,* in order to mitigate the incident situation, will be the result of combined actions from multiple public agencies and private-sector organizations.

The joint COP will be needed, in order to provide the involved actors with a standard and contextual overview of the current traffic status situation. Accessing the same view will provide a common understanding of the information, therefore enabling the traffic managers and any supporting public agencies and private organizations to make coordinated, effective, consistent, and timely decisions.

Ensuring that all the interested parties share the same awareness of the current traffic status situation, makes it possible to better identify 'where' and 'when' that situation downgrades from its desirable traffic flow condition.

The COP can be the result of combining real-time sensing and status data coming from multiple public and private sources, into a common casing. Road safety related data and traffic management related data may be collected via the road infrastructure, via the vehicles or even via nomadic devices. This data can then be aggregated and made available, at the level of the National Access Points, ensuring accessibility for exchange and re-use on a non-discriminatory basis.

The National Access Point may act as a *broker* of information between the different actors, for the building up of the *Cooperative Traffic Management Services*, and as the *gatekeeper* ensuring data privacy and security requirements, e.g..

The *Cooperative Traffic Management Services* can be deployed under different combinations of communication technologies, short range complemented with long range (local and regional measures), therefore, the links between the different systems should be open and loosely coupled.

To assure an efficient collaboration environment, when conducting operations, the COP should provide information (KPI indicators based[63]) to the several actors, regarding the available resources and their current status, as well as any other specific conditions or constraints to take into account in each scenario.

The COP represents as much of the road network as possible, from all Public Road Authorities and cities. It presents the (colour-coded KPIs and LoS) status of roads at the link - or trajectory-level, in measures such as:

- Traffic flow;
- Realised travel time;
- Estimated travel time;
- Traffic speed.

To build this Real-time representation of the (entire) road network, the sensor and status data from multiple public and private sources mentioned above is needed:

- Public and city road authorities' loop, camera and other sensor data, and FVD (when it becomes available);
- Private parties can provide their data on speeds and travel times for their users;
- Public and private information on road works and events;
- The status of bridges and tunnels (open, closed);
- Real-time information on congestion, accidents and incidents as well as safety-related announcements (e.g., wrong-way driver).

Tools are needed to:

[63] Please refer to Section 10.6.5.3 for the concept of Level of Service.

- Fuse these data;
- Produce the KPIs on the link or trajectory level, and;
- Update the COP.

Each public and private organization and user, of the COP can filter and translate the received information to their own context and boundaries, and configure and deploy their own services, aligned by the same common goals and taking into consideration the operation of each other.

The COP will require the private sector, so far reluctant, to open up for the benefits of sharing their data with the public sector.

10.6.5 Building Blocks for digital Traffic Management Plans

Connectivity and automation are already having an impact on the 'static' Regulatory framework[64]. The same is expected for the 'dynamic' traffic regulations. Traffic Circulation Plans and Traffic Management Plans will need to be deployed differently in the future.

Traffic Managers and public authorities will have to adapt their current procedures, accordingly, closing in the gap between the *vehicle* and the *road*.

The group concluded that public authorities will continue commanding traffic. Also that *Cooperative Traffic Management Services* depend upon the performance of all involved players – orchestration of services.

In order for the Public authorities to play the role of the *orchestra conductor*, the Traffic management Plans need to be digitalised into a 'standardized exchangeable data'. This way the plans can be well communicated, understood and, when required, timely executed.

Acting as fleet managers, the OEM's and Service Providers are expected to have a much bigger role on influencing traffic behaviour, therefore alignment of actions and collaboration will establish mutual benefits when balancing individual and collective needs.

In order to develop the digitalisation of the Traffic Management Plans that are needed for *Cooperative Incident Management Services*, the group agreed on the need to develop a set of tools, following a building block approach, and taking into account some requirements:

- ***Requirement:*** to ensure flexibility, the tools to develop the *Cooperative Traffic Management Services* shall be modular, scalable, replicable and compliant with standards.
- ***Requirement:*** the *traffic management related data* shall meet the requirements of the different stakeholders.

[64] Vienna and Geneva Conventions – linked with WG1 and WG29

• ***Requirement:*** Traffic measures can be provided and conveyed, either by public bodies or private organizations, but only the public sector has the authority to issue mandatory traffic measures.

10.6.5.1 Classification of Roads

A *Road Classification building block* is considered necessary to establish a traffic network flow prioritisation. Roads physical characteristics that are relevant for traffic flow efficiency, shall to be taken into account, when defining the basic requirements for the classification of the roads (number of lanes, allowed speed, number of intersections, spacing between intersections, may be used e.g.). This activity shall be carried out by Public authorities acting either as Road operator or traffic manager. Figure 15 shows a road classification with 5 levels of prioritisation. Route recommendations can be tailored and profiled for different user groups, such as freight trucks, electric vehicles and passenger transport.

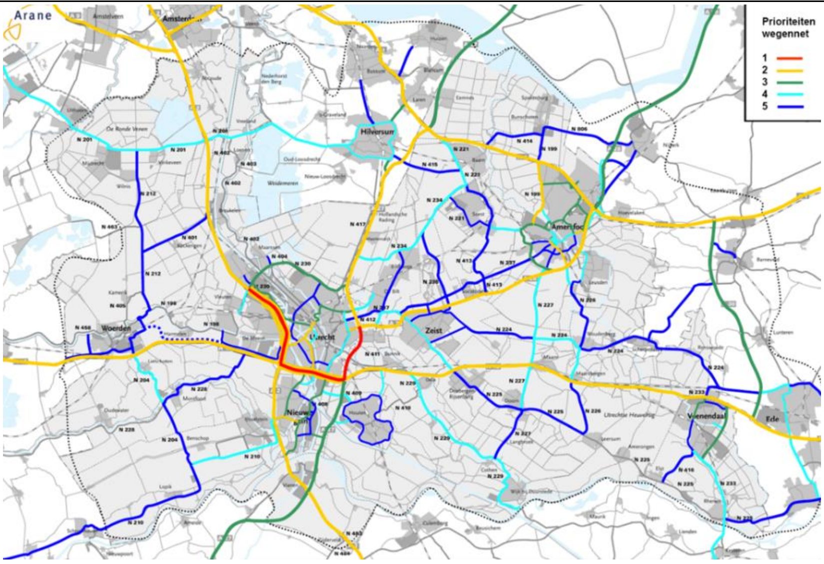

Figure 15: Example of Classification / Prioritisation of Roads

10.6.5.2 Geo-fencing mechanism

Zoning is tool of urban planning used by city administrations to map areas in which certain land uses are permitted (e.g. residential, industrial). The *geo-fencing mechanism* building block aims to decode the city's view of its territory, into *traffic management related data*. It acts as an interface between the city and third parties, namely service providers.

The purpose of the *geo-fencing mechanism* is also to help Service Providers improve their algorithms and propose better routing alternatives, in line with the public's authority expectations. Figure 16 shows an example of zoning.

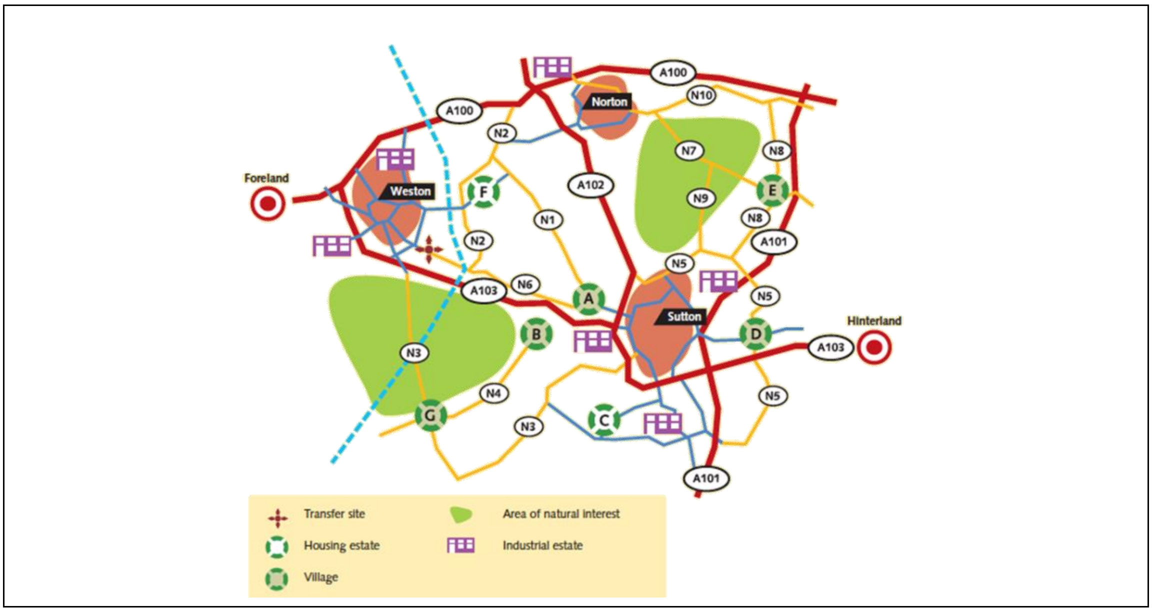

Figure 16: Example of Zoning

Service providers may use different models to develop the concept, such as rewarding specific behaviour, creating incentives, structuring virtual delays in certain areas of the city, due to vicinity e.g. to residential areas. The *geo-fencing mechanism* shall be the result of public and private mutual understanding.

The *geo-fencing mechanism* was based on the day 1.5 service, 'Zone access control for urban areas'.

Both, the classification of roads as the geo-fencing mechanism are two, well-known, low-tech tools put into a high-tech form that any city is able to use across Europe.

10.6.5.3 Network performance Level of Service (LoS)

'Quality of service requires quantitative measures to characterize operational conditions within a traffic stream. Level of service (LoS) [65] *is a quality measure describing operational conditions within a traffic stream, generally in terms of such services measures as speed and travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience'*

Therefore, constant monitoring and assessing the *network performance Level of Service (LoS)* is necessary to manage traffic flow efficiency.

While sharing the same overview and understanding of the traffic status operational picture, it becomes easier for the different actors to establish their agreements. These agreements help clarify when measures are necessary and identify who will put them in place.

[65] *in Highway Capacity Manual* - http://www.trb.org/publications/hcm6e.aspx

Travel time or speed and volume were presented as adequate performance indicators for assessing the correspondent *LoS*. Establishing minimum *LoS* will depend on the *road classification* and the nature of the incident (planned or unplanned).

10.6.5.4 Triggering conditions

The *trigger conditions* establish the point in which the need to engage a Cooperative Traffic Management Service becomes clear. After downgrading to a pre-established minimum *LoS*, triggering the appropriate traffic measures becomes essential to implement, in order to restore safe and flow efficient conditions.

The *triggering conditions* need to be commonly agreed upon. They set the start of the orchestration process, combining pre-established actions from the different actors – in other words, the beginning of the deployment of Cooperative Incident Management.

Figure 17 summarises the steps to establish a Cooperative Management Process.

The same Cooperative Incident Management Local and Regional measures/actions can be adopted to face different events e.g. congestion, roadwork or planned events.

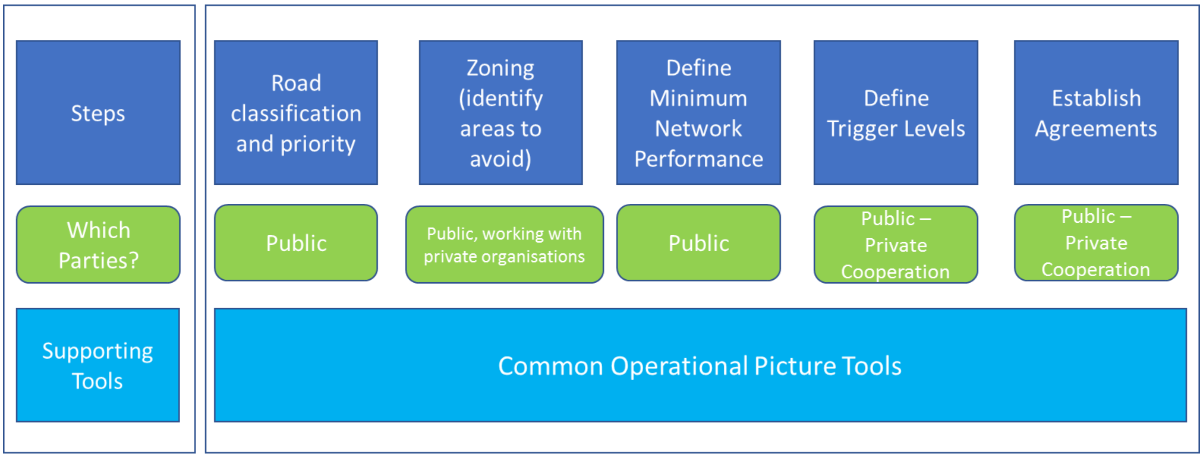

Figure 17: Establishing a Cooperative Incident Management Process

10.7. Recommendations and Follow-up actions

This chapter describes the outcome, conclusions and recommendations of the working group regarding the top down strategic approach and the development of bottom-up operational tolls, taking into account standardisation needs, positions of stakeholders regarding the functional, procedural and organisational changes needed to collect the benefits of connectivity and automation into road operation and traffic management, in order to achieve the policy objectives of safe, environmentally friendly and efficient mobility.

The list of recommendations is looking into a European collaborative roll-out of enhanced traffic management services for future automated and connected mobility.

The following list of recommendations has been agreed upon by the Working Group Members:

10.7.1 Recommendations

The Working Group Experts, unanimously, agreed to recommend:

- To develop the **building blocks** for digital Traffic Management Plans (TMPs) and Traffic Circulation Plans (TCPs), specifically:
  - Classification of Roads;
  - Geo-fencing mechanisms;
  - Network performance LOS;
  - Agreement to the triggering conditions.

  for the deployment of Cooperative Incident Management.
- To develop each of the **building blocks into a new (de-facto) standard**, being the result of mutual public and private understanding;
- To develop the building blocks for digital TMPs and TCPs **taking into account the public's authority hierarchy**, including enforcement bodies, with competences for the same geographical area, e.g. local, regional, national or cross border.
- To develop the building blocks for digital TMPs and TCPs using an **'ITIL'**[66] **framework**, establishing the minimum common functional and organizational needs between the stakeholders.
- To develop **pre-established digital TMPs**, describing the local and regional measures/actions to face e.g. recurrent congestion situations, roadwork or planned events.
- To develop the building blocks in a way that allows them to be combined into a digital TMPs and **assembled 'on the fly'**, to react to unexpected traffic conditions or situations.
- To develop **tailored and profiled digital TMPs** route recommendations to address different user groups, such as freight trucks, electric vehicles or passenger transport.

[66] https://en.wikipedia.org/wiki/ITIL

- To develop **additional standards for Traffic Management** where necessary. They should:
    - specify the necessary data definitions, security and functionality;
    - enable the local policy for traffic management roles and responsibilities to be accessible on a national level;
    - be interoperable and trusted for automated driving on a European level;
    - combine with other standards under development such as the Traffic Management set of standards from the CEN WG on Urban ITS, METR (Management for Electronic Traffic Regulations), and LDM (Local Dynamic Map);
    - be investigated (standards and specifications) to become (eventually) mandatory or included within a Delegated Regulation.
- To develop a **digital library of TMPs and TCPs** to be available via the National Access Points (NAPs). The library should be the outcome of a joint effort from both the private and public sectors.
- To foster cooperation between the different players and **enable coopetition** for the development of the common tools and building blocks.
- To **start piloting** digital TMPs, TCPs and the building blocks, in the comprehensive TEN-T Road Network, including urban nodes. Road authorities/operators should be in charge, acting as the 'orchestra conductor', being the only one to have a "global system" view of the road network and its performance, including safety.
- The **Piloting** scenarios to focus in TMPs and TCPs that can dynamically be altered depending on the actual/forecast traffic conditions, going from planned events (such as road, bridge or tunnel closures, road works, to be presented at an early stage via the NAP) towards unplanned events.
- To make available **funding instruments** (CEF, H2020) taking into account the research and piloting recommendations here described, in order to **start the roll-out of Pan-European** enhanced traffic management services along the comprehensive TEN-T corridors including urban nodes.
- That *Cooperative Traffic Management Services* should be deployed under different combinations of communication technologies, short range complemented with long range, therefore, the links between the different systems should be kept open and able to be **loosely coupled**.

- **This work to continue**, beyond the second phase of the C-ITS Platform, under the European's Commission coordination.

10.7.2 Follow-up actions

After finalising the set of recommendations, the Working Group recognized three topics as the most relevant for starting the Pan European rollout of *Cooperative Traffic Management Services*:

1. *Sharing of Safety related traffic information*: EC published delegated regulation (EU) No 886/2013 on 15 May 2013, addressing data and procedures for the provision, where possible, of road safety-related minimum universal traffic information free of charge to users. C-Roads is deploying in several European corridors, pilot projects to deploy C-ITS Day 1 services, also addressing primarily safety related information. This information should be made available and accessible via the national access point, as required by the Delegated Regulation for the TEN-T Corridors. At a later stage it should be complemented with information coming from all types of road networks.

2. *Digital and standardized availability of Traffic management measures including Traffic Management Plans (TMPs)*: EC published delegated regulation (EU) No 962/2015 on 18 December 2014 addressing the provision of EU-wide real-time traffic information services, including ‘temporary traffic management measures’ and ‘traffic circulation plans’. Combining standardisation efforts at this level, both from CEN TC 278[67] WG17 (Urban ITS) and WG8 (Road Traffic Data – DATEX), will help bring closer together the ITS&C-ITS and the Road Infrastructure Management communities. The work being carried out for the Management for Electronic Traffic Regulations under Standardisation Mandate M/546, is helping cities to face traffic problems by setting up temporary restrictions, geographically limited, sometimes down to lane level or parking bay restrictions. The synergies with the DATEX Community using similar tools to develop Traffic Management Plans along the TEN-T Corridors are obvious. Accessibility of this 'regulatory digital information' and 'traffic management measures' digitally and electronically, is of key importance for the added value of Real time services, in particular for nomadic devices, but needs to be developed in a coordinated way to avoid fragmented National profiles.

3. *Identify the appropriate win-win agreements to support the cooperative traffic management service value-chain*: As the complexity for providing the services will increase, with connectivity and automation, some of the traditional roles will have to be rethought to avoid stakeholders from working against each other. The same

[67] http://www.itsstandards.eu/index.php/tc278

stakeholder can be a producer of data as well as a consumer of data, embodying different roles along the service value chain. Road Safety and Traffic Management efficiency improvements were, unanimously, seen as the most obvious starting point to look into the future Governance framework models. Assessing performance and building a common operational picture will help the coordination between the different actors, as well as their efforts. It will also help the network flow efficiency and safety to improve. The 'orchestration of the services' will require an 'orchestra conductor' and this role shall indisputably remain under the public's authority umbrella.

10.8. Annexes

EnTM - Annex I: Reference projects

EnTM - Annex II: The Strategic approach