MERIDIAN

Report

T1.04 Knowledge Building: C-ITS

Sub-task T1.04.02
C-ITS

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Document Information

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Preface

The T1.04 Knowledge Building workshops on C-ITS were organized as part of the horizontal task T1.04 of work package WP1 ‘Project Management and Knowledge Building’ of the Meridian project.

The purpose of task T1.04 is to exchange and build up knowledge on relevant topics, amongst others Digital Infrastructure, C-ITS, Bottleneck and Digital Corridor Management and Multimodal Services, etc.

The workshops summarized in this report are focused on the topic of **C-ITS**, and selected areas of interest thereof.

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1 Abbreviations

C-ITS	Cooperative Intelligent Transport Systems
C-V2X	Cellular Vehicle to everything (3GPP standard)
5G	Fifth-generation technology standard for cellular networks
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITS G5	ETSI standard for ITS in 5.9 GHz band. IEEE 802.11p. WiFi-p.
NAPCORE	National Access Point Coordination Organisation for Europe
OEM	Original Equipment Manufacturer, i.e. car or truck manufacturer
PAPI	Pen and Paper phone Interview
PKI	Public Key Infrastructure
RTTI	Real-Time Traffic Information
R-ITS-S	Roadside ITS station
RWW	Road Works Warning
SRTI	Safety Related Traffic Information
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle to everything

2 Introduction

This report is a summary of the workshops that were organized by the Meridian corridor project as part of its knowledge exchange and knowledge building task, and more particularly on the topic of **C-ITS** (Cooperative Intelligent Transport Systems). The workshops were organized either as on-site meetings, or as on-line events in order to attract the necessary experts. The workshops were held in March 2023, July 2023 and November 2023.

The workshops were organised around a number of thematic sub-topics, being agreed upon and worked out during interviews.

- ★ C-ITS presentations of the Meridian partners,
- ★ Eco-system and end users: importance, financial and economic sustainability and facilitation
- ★ Technology choice and integration in operational and functional processes
- ★ Regulation and standardization.

The main purpose of knowledge exchange and knowledge building task of Meridian is to exchange experiences, issues and solutions between the different partners of the Meridian corridor project.

Besides presentations by the different experts of the respective C-ITS implementation projects (grouped in work package WP3), discussions and knowledge exchange were organized as PAPI, pen and paper phone interviews.

3 Knowledge building background

A knowledge building action focusses on increasing the knowledge level and the level of understanding with the participants. This objective is central in the current activity. The topic at hand concerns (different types of) C-ITS services, a subject which is becoming increasingly important for public and private stakeholders alike.

The MERIDIAN steering committee meeting (Ghent, 15 March 2023 – see chapter 4) was used to introduce the Knowledge Building activities on C-ITS within the MERIDIAN project. More precisely, it was used to identify possible topics on which a dedicated knowledge building activity would be considered useful for the participants. As a result, 8 (different) C-ITS topics were identified. Information about these 8 topics was presented during an online workshop (Wednesday, 5 July 2023 – see chapter 7) during which the participants could discuss the content and relevance of the different topics for their organization. This was used to restructure and select 3 topics for the eventual PAPI, which was executed in August and September 2023. As a result of the analysis of the different PAPI, an additional knowledge-building activity was initiated in the format of a workshop, which was held on 30 November 2023 (see chapter 10).

The 8 original topics are presented in chapter 6:

1. Eco-system facilitation: connecting stakeholders
2. Data quality
3. Technology used / how is the technology used and integrated in the processes
4. Financial & economical sustainability – business model challenges

5. Regulation & standardisation
6. Data security
7. End user connection – impact of end users – numbers of end users / scalability
8. (End user) reimbursement models to build engagement.

The outcome of the online workshop on 5 July 2023 is presented in chapter 8 with the composition and selection of the 3 topics and PAPI questions.

Three topics were identified during the online workshop on 5 July 2023 with the purpose of initiating a PAPI to collect relevant information and know-how. The first topic is a composition of the originally presented topics 1, 4 and 7. As such, the topic (eco-system and end-users) has so far not been the subject of large (dedicated) actions within existing projects and programs such as C-Roads, Intercor or NAPCORE). The second topic (Technology choice and integration in operational and functional processes) and third topic (Regulation and standardization) on the other have been the subject of such large (dedicated) actions. At the same time, they are less suitable to be covered sufficiently in a knowledge-building activity using PAPI-style methodologies. As a result, a distinction will be made:

- Topic 1 will be the subject of a wide-range PAPI with the purpose of collecting and gathering know-how from MERIDIAN partners.
- Topic 2 and 3 will be the subject of a limited-range PAPI with the purpose of outline specific information requests for which we can make use of the MERIDIAN network to reach out to projects such as C-Roads, NAPCORE, etc. to tap into their know-how and either disseminate their know-how throughout MERIDIAN or create a liaison with the persons who have such knowledge.

The outcome of the PAPI execution is presented in chapter 9.

The next step, after the PAPI, is the execution of a workshop which aims at mitigating deficits that were brought forward during the PAPI. The preparation steps for the workshop and the main findings are presented in chapter 10.

4 Workshop 15 March 2022

4.1 Agenda

Day 1 – 15th of March, 2023

Time	Agenda Item	Lead/Speaker	Supporting Documents
08:45	*Welcoming Coffee*		
14:15	*Coffee Break*		
14:35	**Presentation / Introduction of 4 C-ITS project to kick start the Knowledge Building & Sharing**		
	• Introduction	Lars	
	• T3.01 Mobilidata / BE Agency for Roads and Traffic	Ben or Erika	
	• T3.02 Phase II: C-ITS Road works warning roll-out / DE Die Autobahn	Susanne Schulz	
	• T3.03 C-ITS Corridor Services to the port of Livorno / IT Autorita di Sistema Portuale del Mar Tirreno Settentrionale	Elena	
	• T3.04 Safety Priority System- I2V data provision for in-car warnings / NL (Ministerie I&W)	André	
15:45	**Discussion on C-ITS Knowledge Building**	All	
16:15	*Coffee Break*		
16:30	**Demonstration Mobilidata iTLC use cases**	-	
17:00	*End*		

4.2 Kick-off

The kick-off of the C-ITS knowledge building and knowledge exchange sub-task of task T4.01 was organised during the Ghent steering committee on 15th March 2023.

The four Meridian implementation tasks identified in WP3 being:

- ★ T3.01 BE (FL) – Mobilidata
- ★ T3.02 DE (AB) – Phase II: C-ITS Road works warning roll-out
- ★ T3.03 IT (ASP) – C-ITS Corridor Services to the port of Livorno
- ★ T3.04 NL (Ministerie I&W) – Safety Priority System - I2V data provision for in-car warnings,

were presented and discussed during the kick-off.

In addition to these Meridian corridor related implementation tasks, experts from following organisations were consulted or gave presentations of their C-ITS implementations at later workshops:

- ★ Italy (Autostrada del Brennero)
- ★ Germany (Landesbaudirektion Bayern)
- ★ Ireland (Transport Infrastructure Ireland).

4.2.1 T3.01 – Mobilidata

Speaker(s): Erika Decorte, Flemish Agency for Roads and Traffic

Erika gave a presentation on the Mobilidata programme of the Flemish government, of which task T3.01 is a subset. The goals of the programme were explained, as well as the 31 use cases grouped in Traffic Regulation and Advice (3), Personal Support / Risk Reduction (13), intelligent Traffic Light Controller (10), Navigation and Parking Management (3) and Policy Support (2) uses cases. The timeline was explained as well as the way forward and the lessons learnt.

4.2.2 T3.02 – Phase II: C-ITS Road works warning roll-out

Speaker(s): Suzanne Schulz, die Autobahn

Suzanne presented the roll-out project of the road works warning (RWW) implementation. Including the C-ITS vision, the traffic management strategy of die Autobahn as well as the drivers for the RWW roll-out. Focus was laid on road works warning roll-out of 75 R-ITS-S (roadside ITS stations) on the C-ITS Corridor (A3 motorway) which were installed and in regular operation. Challenges ahead were summarised as well as guidelines for future activities.

4.2.3 T3.03 – C-ITS Corridor Services to the port of Livorno

Speaker(s): Elena Bargagna, Northern Tyrrhenian Sea Port Authority System

Elena explained the development of Day 2 C-ITS services relaying the port of Livorno to the hinterland. Emphasis was laid on the primary and secondary end users, on the use cases, i.e. bottleneck removal, safety information and smart truck parking. The technical aspects of the project were explained, as well as the challenges.

4.2.4 T3.04 – Safety Priority System - I2V data provision for in-car warnings

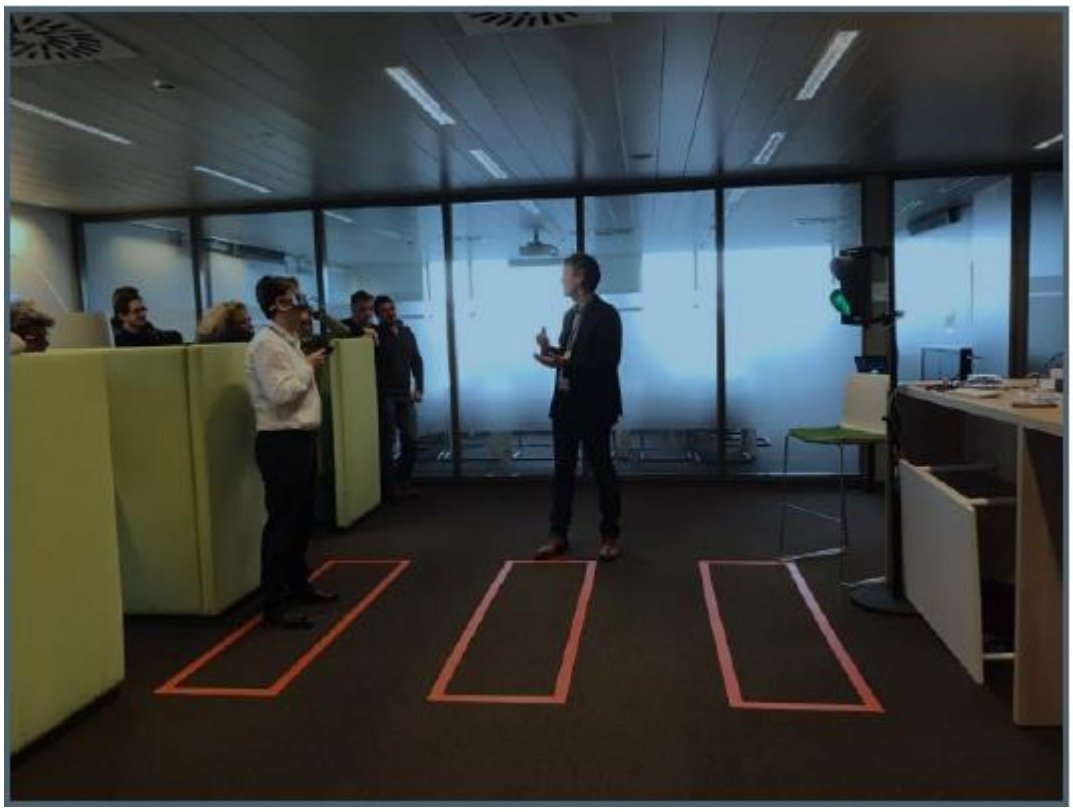
Speaker(s): Bas Kocken, Rijkswaterstaat

Bas explained the 5 use cases (Jam Tail Warning, Emergency Vehicle Approaching, SRTI, Traffic Laws, and Smart Routing) deployed in the Safety Priority System project in the Netherlands. The reimbursement model was explained. Except for the SRTI use case where no reimbursement is provided since the delegated regulation (EU) 886/2013 and the ITS Directive 2010/40/EU state that road safety-related minimum universal traffic information should be free of charge to end users. Bas focussed also on challenges/bottlenecks and on lessons learnt / factors of success / topics considered as good practice.

4.3 Demonstration Mobilidata iTLC Use Cases

The C-ITS knowledge building workshop during the first day of the Steering Committee in Ghent was concluded with a demonstration on smart traffic lights. Inside the building of the Flemish road authority Agentschap Wegen en Verkeer (AWV) the Steering Committee participants got a demonstration on the latest developments and future possibilities of using smart traffic lights.

In this demonstration a portable traffic light was installed in the room next door, and under the guidance of Bart Lowyck the Steering Committee witnessed another use case on smart traffic lights: safe crossing for blind people.



The idea is that the application recognizes the proximity of the smart traffic lights and communicates to the blind people about either a red or green light by different frequencies of vibrations. In the recreated zebra crossing, a blindfolded volunteer was given a phone with the application. When the frequencies of vibrations of the phone changed, he should recognize that the traffic light turned green and he can safely cross the road. This demonstration showed that C-ITS can also improve safety and inclusivity of disabled people in traffic.

5 Overall PAPI structure, workshop structure and functioning

A PAPI (in this case, a pen and paper phone interview) is a qualitative methodology to gain insight in the knowledge and know-how from a respondent on a specific topic. It will, within MERIDIAN, be used to gain insights on 3 C-ITS topics.

The PAPI consists of the following elements:

- A short introduction (1 page)
- The topic introduction (1 to 2 pages per topic)
- A set of questions that can be prepared by the respondent (and pre-sent do the interviewer)
- The effective interview
- Response analysis
- Feedback.

The PAPI main body, i.e. the questions is structured as follows:

- Topic definition:
  - Paragraph on what we think it means
  - Verification if this is what respondent also understands it to be
- Precise problem example (what is your experience)
  - What was “this type of issue” in your case
  - Specific questions per topic (see below for a preliminary set of questions).

The preparation of a PAPI requires:

- The identification of the correct respondents
- Data/Phone interview setup
- Topic definitions (see below) & informing of workshop participants.

The outcome of the analysis of the PAPI results is valuable to be used in, for example, dedicated workshops where additional knowledge building activities are executed. In general, knowledge building workshops have three main elements:

- The creation of a mutual (knowledge) starting point or discussion starting point
- Interaction by the different participants, under guidance of a workshop lead, with the purpose of extrapolating latent knowledge, bottlenecks, knowledge or application gaps
- Outlining of solutions, future steps, etc.

6 Topic definitions – initial list

6.1 Topic 1 - Eco-system facilitation: connecting stakeholders

What is it?

An eco-system is the structure or network of organizations, companies and individuals that get to produce, procure and/or use a product, such as a C-ITS service. An eco-system includes suppliers, distributors, users, costumers, etc. It also includes both the positive (cooperative) as well as negative (competitors) associations. It includes both public as well as private stakeholders.

In other terms, an eco-system connects primary, secondary and tertiary stakeholders. Primary stakeholders are the end-users of a product or service. Depending on the service, examples are drivers, road authorities, etc. Secondary stakeholders are not the end-user of a product or service, but they are in direct contact with the primary end-user. For example, the OEMs, service providers, etc. Tertiary stakeholders are not directly in contact with the products or services, but somehow contribute in organizing, paying, facilitating or enabling them. For example, legislative bodies, regulators, etc.

Why is it important to create an eco-system?

Having an eco-system that connects the three types of stakeholders improves the stability and viability of the C-ITS service. In the long term, this allows for the continuity of different aspects of the service, not in the least the actual usage thereof.

The creation and maintenance of an eco-system is as important as the development of the C-ITS product or service itself. It allows products or services to be developed, rolled-out and maintained up to the level where they function in a cost-efficient way.

If a sustainable eco-system cannot not developed, it can be indicative of different issues such as: (1) the product or service is not a viable product or service, (2) the product or service serves no end-user market, (3) the product or service has a skewed or biased cost/benefit ratio, (4) the different stakeholder groups are not aligned over the (development, roll-out, use, …) of the product or service, (5) etc.

6.2 Topic 2 - Data Quality

What is it?

Data quality is directly linked to the suitability or fitness of data for the use for a specific purpose. Depending on the use, up to 12 attributes are considered when identifying the fitness of data for its purpose. A subset of 7 attributes is often considered:

- Accuracy: when a suitable “ground truth” (or source of truth) is identified, the accuracy of data represents how good your data or data source corresponds with this ground truth. It may be useful to have different comparison datasets available for appropriate triangulation of accuracy.
- Completeness: the percentage or amount of data that is usable. A high ratio of missing or incomplete values leads to wrong analyses (i.e. biased or misleading) as the chance is higher that the data (sample) that you are using is not representative for the “real world”.

- Consistency: when different datasets or data sources are available, this allows for a check on the consistency of the data. A high correlation of the datasets is an indicator of consistency.
- Currency or recency (sometimes also timeliness): the degree to which the data is current with the world it is supposed to represent or model. Depending on the end-user needs, a higher or lower level of currency may be required.
- Relevance: not all data is equally useful or relevant for fulfilling the end-user needs or requirements. The relevance of data represents the correspondence or consistency between the data and the user's requirements.
- Uniqueness: the amount of duplicate data in a dataset.
- Validity: the extent to which the data conforms to the expected format, type, and range.

The use of such attributes facilitates the proposition of clear targets for data providers to achieve to obtain source data that is usable to create or provide C-ITS services. It allows, in other words, to create valuable dashboards, such as:

https://www.datapedia.nl/datatop15/nodes/datatop15.

Why is it important to identify data quality requirements, and to achieve them?

One of the foundations for functional C-ITS products or services is the availability of quality data. Otherwise, like with all ITS services, the quality of the service itself is subpar.

However, it is not enough to just have “high” data quality, it is important to identify those parameters which are relevant for the end-users (whoever they may be) and obtain the appropriate data quality level. For example, although it would be very nice to have continuously updated information of all fixed traffic signs at all times, this is more than likely overkill, as fixed traffic signs do not change every second. It is more than likely enough to have a regular update on a daily or even weekly basis on possible road sign changes. This is however not the case with digital road signs, as these do change regularly, and it is thus valuable to have near real-time data.

6.3 Topic 3 - Technology used / how is the technology used and integrated in the processes

What is it?

Different types of technology products and services can be used to fulfil a C-ITS requirement. It is even relatively fair to state that for most of the C-ITS services, solutions are available that have evolved from testbed or trial projects and have turned into scaled-up implementation programs or projects. Each (technological) solution comes with specific advantages and disadvantages. It is important to identify these aspects of the solution and make an appropriate choice as to which technology provides a good fit to the C-ITS requirement, as a whole.

Equally important to the actual implementation of the technology solution is the integration of this solution into the working processes with the different (types of) stakeholders. The introduction of a (new) technology into a functioning system often requires existing processes to be slightly altered, personal skills to be trained, responsibilities to be identified, etc.

Why is it important to integrate the technology into functional processes?

The long-term outcome on the effective use of a technology product or service depends on various elements. For example (non-exhaustive): product readiness, cost & pricing, perceived advantages, end user appreciation, etc. One element that is often looked over, or assumed to come automatically if the technology solution fulfils the other criteria, is the integration within existing structures and processes.

Such integration is however very important as it is a facilitator for, for example, follow-up actions, quality control, cost-efficiency optimization, impact maximization, etc. In some extreme cases, it can even be that a perfect product fails because there is no stakeholder to be found where the product is integrated into its functional processes. There is no-one who is responsible for, or willing to actively monitor, follow-up, check, etc. which ultimately results in sub-par usage.

6.4 Topic 4 - Financial & economic sustainability challenges

What is it?

Financial and economic sustainability refers to the ability of the service to operate and generate revenue in a self-sufficient manner over the long term while providing economic benefits to the stakeholders involved.

Financial sustainability focuses on the financial viability and profitability of the C-ITS service. It involves ensuring that the service's revenue streams are sufficient to cover its operational costs, maintenance expenses, and potentially fund future expansions or upgrades. As such, it requires careful cost management, efficient resource allocation, and a sustainable business model that aligns revenue generation with the value provided by the service.

Economic sustainability looks at the broader economic impact of the C-ITS service. It considers how the service contributes to the overall economy by creating jobs, fostering innovation, and enabling for example more efficient transportation systems. Economic sustainability involves analysing the cost-benefit ratio of the service, evaluating its impact on productivity, congestion reduction, fuel consumption, emissions, and safety. Ideally, a C-ITS product or service should deliver economic benefits that outweigh its costs and have a positive impact on society as a whole.

Numerous factors can be considered to achieve financial and/or economical sustainability:

- User Demand and Value: the service should address the needs of its users and provide tangible value, such as improved traffic flow, reduced travel time, enhanced safety, and convenience. Understanding the target audience and tailoring the service accordingly is crucial to attracting users and generating sustained demand.
- Funding Mechanisms: identifying appropriate funding mechanisms is essential for financial sustainability. This can include a combination of public and private funding, grants, user fees, partnerships with stakeholders, or even ad-supported models. Diversifying revenue sources can reduce dependency on a single funding stream.
- Scalability and Cost Efficiency: designing the C-ITS service to be scalable and cost-effective is important for long-term sustainability. This involves utilizing existing infrastructure and technology where possible, optimizing resource allocation, and adopting scalable architectures and platforms that can accommodate future growth without incurring excessive costs.
- Regulatory and Policy Support: favourable regulatory and policy frameworks play a crucial role in supporting the financial and economic sustainability of C-ITS services.

Governments and transportation authorities should create an enabling environment by providing incentives, promoting interoperability, and ensuring fair competition.

- Business Collaboration: collaboration among different stakeholders, such as government agencies, technology providers, vehicle manufacturers, and transportation operators, can contribute to financial and economic sustainability. Partnerships and cooperative arrangements allow for cost sharing, knowledge exchange, and leveraging complementary expertise to achieve common goals.

Why is it important to identify and solve financial & economic sustainability challenges?

By implementing strategies that balance financial viability with economic benefits, a C-ITS service can aim for long-term sustainability and contribute to the advancement of C-ITS products and services.

It is important to notice that these challenges become ever more important when moving away from testbed projects to (large scale) implementation projects as the project (impact) timeframe, the (economic and societal) goals and objectives, and the overall effort takes place over a much longer period of time, and therefor requires a longer sustained effort.

6.5 Topic 5 - Regulation & standardization of C-ITS services

What is it and why is it important?

The regulation and standardization of C-ITS services are essential to ensure interoperability, safety, and efficient deployment of these services across different regions and countries. Several organizations and initiatives are involved in developing regulations and standards for C-ITS. It's worth noting that regulations and standards may vary across different regions and countries. However, efforts are being made to harmonize these standards globally, allowing for seamless interoperability and international deployment of C-ITS services.

Examples of key entities and efforts in this regard are:

- European Union (EU):
  - European Telecommunications Standards Institute (ETSI): ETSI is responsible for developing and maintaining the standards for C-ITS communication, including the ITS-G5 (IEEE 802.11p) and Cellular Vehicle-to-Everything (C-V2X) technologies.
  - European Committee for Standardization (CEN): CEN is involved in developing standards related to the architecture, data exchange, and security aspects of C-ITS.
- International Organizations:
  - International Telecommunication Union (ITU): ITU provides global standards and recommendations for C-ITS communication technologies.
  - ISO/TC 204: ISO/TC 204 is the Technical Committee responsible for developing international standards for Intelligent Transport Systems (ITS), including C-ITS.
- International Initiatives:

- Car 2 Car Communication Consortium (C2C-CC): C2C-CC is an industry-led consortium that focuses on the development and promotion of C-ITS communication standards and interoperability.
- European C-ITS Deployment Platform (EIP): EIP brought together public and private stakeholders to support the deployment of C-ITS services in Europe and facilitate the development of harmonized standards.

These organizations and initiatives work collaboratively to define technical standards, communication protocols, security measures, and interoperability guidelines for C-ITS. The standards cover areas such as vehicle-to-vehicle (V2V) communication, vehicle-to-infrastructure (V2I) communication, data exchange formats, cybersecurity, privacy protection, and service provision.

6.6 Topic 6 – Data Security

What is it?

Data security is a critical aspect of C-ITS services to ensure the confidentiality, integrity, and availability of data exchanged between vehicles, infrastructure, and other stakeholders. Given the sensitivity of the data involved in C-ITS, including location information, personal data, and real-time traffic data, robust security measures are necessary to protect against unauthorized access, malicious activities, and data breaches. Here are some key considerations for data security in C-ITS services:

- Authentication and Access Control: strong authentication mechanisms should be in place to verify the identity of C-ITS participants, such as vehicles, infrastructure components, and service providers. Access control measures should restrict access to authorized entities only, preventing unauthorized access to sensitive data.
- Encryption: data exchanged in C-ITS should be encrypted to protect it from interception and unauthorized reading. Encryption ensures that the data is only accessible to authorized recipients, even if it is intercepted during transmission.
- Data Integrity: mechanisms such as digital signatures and message authentication codes can be employed to ensure data integrity. These measures allow the recipient to verify that the data has not been tampered with during transmission.
- Secure Communication Protocols: C-ITS services rely on communication protocols for exchanging data. Secure and robust protocols should be used, such as Transport Layer Security (TLS) for secure communication over the internet. Additionally, protocols specific to C-ITS, such as ITS-G5 or C-V2X, incorporate security features to protect the communication channels.
- Privacy Protection: C-ITS services often involve the exchange of personal data, such as vehicle identification or location information. Privacy protection measures, such as data anonymization, pseudonymization, and strict access controls, should be implemented to safeguard the privacy of individuals and comply with relevant data protection regulations.
- Security Audits and Testing: regular security audits and vulnerability assessments should be conducted to identify and address any potential weaknesses in the C-ITS

infrastructure. Penetration testing and security assessments can help identify vulnerabilities and ensure that appropriate security measures are in place.

- Security Governance and Compliance: establishing security governance frameworks and compliance programs is crucial for maintaining data security in C-ITS services. This includes defining security policies, procedures, and guidelines, as well as ensuring compliance with relevant industry standards and regulations.

Data security in C-ITS services is a complex and ongoing process that requires a multi-layered approach, involving technology, protocols, policies, and governance. By implementing robust security measures, C-ITS providers can help protect the integrity and privacy of data, ensuring the trust and reliability of these cooperative systems.

Why is it important to maintain data security?

Data security is vital for maintaining the privacy, safety, reliability, and trustworthiness of C-ITS systems. It ensures the integrity of data, protects against cyber threats, fosters user acceptance, and helps organizations comply with regulatory requirements. By prioritizing data security, C-ITS service providers can maximize the potential benefits of these cooperative systems while minimizing risks and vulnerabilities. It is crucial for C-ITS products and services because of following reasons:

- Privacy Protection: C-ITS systems involve the exchange of sensitive data, including location information, personal data, and vehicle-related details. Ensuring data security is essential to safeguard the privacy of individuals and prevent unauthorized access to personal information. Protecting privacy builds trust among users and encourages their participation in C-ITS services.
- Safety and Reliability: C-ITS systems play a significant role in enhancing road safety and traffic efficiency. Data security is critical to maintaining the integrity and reliability of the information exchanged within the system. Malicious activities, such as data tampering or spoofing, can compromise the accuracy of information, leading to incorrect decisions and potentially hazardous situations on the roads.
- Trust and User Acceptance: data security is essential to building trust among users and stakeholders of C-ITS services. When individuals and organizations have confidence that their data is protected, they are more likely to adopt and actively participate in C-ITS systems. Trust in the security of data encourages broader acceptance and uptake of these services, leading to their effective implementation and potential benefits.
- Compliance with Regulations: many regions and countries have specific regulations and data protection laws that govern the collection, processing, and sharing of personal and sensitive data. Maintaining data security in C-ITS systems helps organizations comply with these legal requirements, avoiding potential legal and financial consequences associated with non-compliance.
- Mitigation of Liability and Risks: data breaches and security incidents can have severe consequences, including financial loss, reputational damage, and legal liabilities. By implementing robust data security measures, C-ITS service providers can reduce the risks associated with data breaches and potential liabilities, protecting their own interests as well as the interests of their users and stakeholders.

- Protection against Cyber Threats: as C-ITS services rely on communication networks and infrastructure, they are susceptible to various cyber threats, including hacking, data breaches, and denial-of-service attacks. By maintaining data security, C-ITS systems can protect against these threats and prevent unauthorized access, manipulation, or disruption of the system, ensuring the continuity and reliability of the services.

6.7 Topic 7 - End user connection – impact of end users – numbers of end users

What is it?

End users play a crucial role in the success and effectiveness of C-ITS services. They are literally the end in the stakeholder chain, being the direct actors and beneficiaries of a C-ITS product or service. End users can be different persons or entities. They can be, for example, private or professional road users, but they can also be the road authority, transport company or other public or private parties.

End users are integral to the success of C-ITS services. Their satisfaction, acceptance, and active engagement drive the adoption and usage of services, influence traffic behaviour, improve road safety, contribute valuable data, and provide insights for service improvement. By focusing on end users' needs and ensuring their positive experience, C-ITS services can effectively deliver their intended benefits and transform transportation systems towards greater efficiency, safety, and sustainability.

In order to achieve significant societal impact (effectively also leading to economic sustainability), it is important that a significant number of end users make use (on a regular basis) of the C-ITS product or service.

Why is it important to obtain a significant number of end users?

The most direct reason is that a significant number of end users is also a direct way to create a viable and sustainable eco-system. It is, in short, a way to guarantee that different stakeholders (who may have different interests) have a reason to remain active within the eco-system.

Some elements may help in reaching significant number:

- User Experience and Satisfaction: end users' satisfaction is a key factor in the adoption and continued usage of C-ITS services. By considering the needs, preferences, and feedback of end users, service providers can design and deliver services that offer a positive user experience. A user-friendly interface, intuitive features, and personalized services contribute to higher user satisfaction, fostering long-term engagement and usage.
- User Acceptance and Adoption: end users' acceptance and willingness to adopt C-ITS services are pivotal for their successful implementation. Understanding the expectations and concerns of end users helps in designing services that align with their needs and address potential barriers to adoption. Engaging with end users during the development and deployment phases enhances the chances of widespread acceptance and adoption of C-ITS services.

The outcomes (or impacts) could then be:

- Behavioural Changes and Traffic Efficiency: end users' active participation in C-ITS services can drive positive behavioural changes in their driving patterns and

decision-making. For example, by providing real-time traffic information, road condition alerts, or optimized routing suggestions, end users can make more informed choices, leading to smoother traffic flow, reduced congestion, and improved overall traffic efficiency. The collective impact of user engagement can contribute to more sustainable and efficient transportation systems.

- Safety Benefits: C-ITS services offer various safety-enhancing features, such as collision warnings, emergency braking assistance, and vulnerable road user alerts. The active involvement and responsiveness of end users to these safety warnings and recommendations are crucial for preventing accidents and minimizing risks on the roads. End users' awareness, adherence to safety guidelines, and prompt reactions can significantly contribute to improving road safety outcomes.
- Data Contributions: end users generate a wealth of data through their interaction with C-ITS services, including real-time traffic information, vehicle sensor data, and road condition reports. This user-generated data is valuable for enhancing the accuracy and effectiveness of C-ITS services. Aggregated and anonymized data from end users can be used for traffic management, predictive analytics, and infrastructure planning, leading to better-informed decision-making and more responsive transportation systems.
- Continuous Improvement and Feedback: end users' feedback, suggestions, and usage data provide valuable insights for service providers to identify areas for improvement and further development. By actively engaging with end users and soliciting their feedback, service providers can continuously enhance the functionality, reliability, and user experience of C-ITS services. End users' input contributes to the iterative refinement of services and the delivery of more relevant and valuable features.

6.8 Topic 8 – (End user) reimbursement models to build engagement

What is it?

To build engagement with C-ITS services, reimbursement models can be implemented to incentivize and encourage end users to adopt and actively participate in these services. Some examples of reimbursement models that can help drive engagement are:

- Usage-Based Reimbursement: this model involves reimbursing end users based on their actual usage of the C-ITS services. For example, a portion of the toll fees or congestion charges paid by users can be refunded or discounted based on their usage of C-ITS-enabled vehicles. This provides a financial incentive for users to actively engage with the services and encourages their continued participation.
- Performance-Based Reimbursement: in this model, end users can receive reimbursements based on their performance in utilizing C-ITS services. For instance, users who consistently follow recommended routes to optimize traffic flow or demonstrate safe driving behaviour through cooperative safety applications can be eligible for financial rewards or reduced insurance premiums. This approach encourages users to actively utilize the services and promotes positive behavioural changes.

- Data Contribution Reimbursement: C-ITS services heavily rely on user-generated data to improve their accuracy and effectiveness. In this model, end users can be reimbursed for contributing their data to the C-ITS ecosystem. By sharing their anonymized data on traffic conditions, road hazards, or parking availability, users can receive benefits such as reduced tolls, access to preferential parking, or discounts on related services. This encourages data sharing, enhances the overall quality of services, and creates a sense of community engagement.
- Partnership Programs: reimbursement models can involve partnerships with various stakeholders, such as insurance companies, vehicle manufacturers, or service providers. For example, insurance companies can offer premium discounts to users who adopt and regularly utilize C-ITS services, as these services can contribute to safer driving practices. Vehicle manufacturers can provide incentives or discounts for vehicles equipped with C-ITS technologies, fostering user engagement and adoption.
- Loyalty and Rewards Programs: implementing loyalty programs that offer rewards or points for using C-ITS services can drive engagement. Accumulated points can be redeemed for various benefits, such as discounts on fuel, vehicle maintenance, or even non-transportation-related products and services. These programs create a sense of value for users and encourage continued participation.
- Public Funding and Subsidies: governments or transportation authorities can provide financial incentives or subsidies to users who actively engage with C-ITS services. This can include reimbursement of a portion of the service fees, discounted tolls or parking fees for C-ITS-enabled vehicles, or access to exclusive privileges, such as high-occupancy vehicle (HOV) lanes.

It's important to note that the specific reimbursement models and strategies may vary depending on the region, stakeholders involved, and the nature of the C-ITS services. The effectiveness of these models relies on careful design, clear communication of the benefits, and collaboration with relevant partners to ensure sustainability and maximize user engagement with C-ITS services.

Why are reimbursement models important?

Reimbursement models can provide a more direct or visible way of providing end users or different types of stakeholders with positive impacts from the use of C-ITS services. In particular in the case of money-driven entities or companies, this is an approach that can be considered.

7 Workshop 5 July 2023

7.1 Agenda

MERIDIAN C-ITS workshop
Date: 5th of July 2023: 13h00 – 16h00

Time	Agenda Item	Lead/Speaker	Supporting Documents
13h00	Welcome & Introduction	Jean	
	Presentation of several C-ITS sub-topics (outcome of the Ghent kick-off meeting)	Lars	
	Selection of 3 out of 8 topics for in-depth knowledge building	Lars/All partners	
	C-ITS along A22 Brenner highway	Ilaria	
	C-ITS in Ireland	Munya	
	Coffee Break		
	Presentation of questionnaire	Lars	
	Identification of PAPI contact person/organisation + interview timeslot	All	*XLS*
	Next workshop date		
	AOB		
	End		

The 5 July 2023 C-ITS workshop summarized the outcome of Ghent kick-off meeting: the 8 C-ITS topics were summarized, and the participants could discuss the content and relevance of the different topics for their organization. This was used to restructure and select 3 topics for the PAPI, practical arrangements were taken to allow the execution of the PAPI in August and September 2023.

In addition, two additional C-ITS project presentations were given by two additional Meridian partners.

7.2 C-ITS along the A22 Brenner highway - Italy

Speaker(s): Ilaria De Biasi

Ilaria gave a presentation of the C-ITS roll-out along the A22 Brenner highway, explaining the hybrid approach of both short range (ITS G5, 802.11-p) and long range (4G cellular) implementations, as well as the implemented Day 1 and Day 1.5 services. She stressed the importance of cooperation among the main actors involved in the C-ITS ecosystem, i.e. the infrastructure provider, the telco operator and the car manufacturers, without which it wouldn't have been possible to implement CCAM services. She concluded with the learnings on the challenges.

7.3 T4.07 - Cork C–ITS - Ireland

Speaker(s): Munya Mutyora

Munya explained the planned C-ITS roll-out at approaches to Cork's Dunkettle Interchange and Jack Lynch Tunnel (N40/M8/N25/N8) and the planned use cases / C-ITS service categories. The involved stakeholders in the ecosystem were explored and categorised in road/transport authorities, local councils, road network operators, end-users, C-ITS and ITS equipment manufacturers, smart mobility partners, international partners, cellular telecommunication companies, vehicle manufacturers, standardisation organisations, academia and some other stakeholders. And the stakeholder engagement process was explained. The C-ITS high level architecture was explained and its integration in the Dublin Motorway Operations Control Centre (MOCC).

8 Topic definitions – final selection for PAPI Round 1

During the workshop of 5 July 2023 the 8 potential C-ITS topics were discussed and prioritized to 3 (restructured) topics for the PAPI. This chapter consists of the definitions, information and questions the partners were given as preparation for the PAPI around the 3 selected topics.

8.1 Topic 1: Eco-system and end users: importance, financial and economic sustainability and facilitation

What is it?

An eco-system is the structure or network of organizations, companies and individuals that get to produce, procure and/or use a product, such as a C-ITS service. An eco-system includes suppliers, distributors, users, costumers, etc. It also includes both the positive (cooperative) as well as negative (competitors) associations. It includes both public as well as private stakeholders.

In other terms, an eco-system connects primary, secondary and tertiary stakeholders. Primary stakeholders are the end users of a product or service. Depending on the service, examples are drivers, road authorities, etc. Secondary stakeholders are not the end-user of a product or service, but they are in direct contact with the primary end-user. For example the OEMs, service providers, etc. Tertiary stakeholders are not directly in contact with the products or services, but somehow contribute in organizing, paying, facilitating or enabling them. For example legislative bodies, regulators, etc.

End users play a crucial role in the success and effectiveness of C-ITS services. They are literally the end in the stakeholder chain, being the direct recipients and beneficiaries of a C-ITS product or service. End users can be different persons or entities. They can be, for example, private or professional road users, but they can also be the road authority, transport company or other public or private parties. The identification of the end-users depends on the nature of the C-ITS service. For example, most of the Day 1 and Day 1.5 C-ITS services are warnings focusing on providing road users (drivers) with information relevant to a safe and efficient execution of the driving task. Other C-ITS services however focus more on the road authority as an end-user by providing them with relevant information on the status of the road, its use, etc.

Why is it important?

For both the eco-system and well as the end users, it cannot be overstated how important they are to the success of C-ITS services. Their satisfaction, acceptance, and active engagement drive the adoption and usage of services, influence traffic behaviour, improve road safety, contribute valuable data, and provide insights for service improvement. By focusing on the eco-system, stakeholders and end users' needs and ensuring their positive experience, C-ITS services can effectively deliver their intended benefits and transform transportation systems towards greater efficiency, safety, and sustainability.

What is primordial for the eco-system, its stakeholders and the end users?

As such, it is very important to support and facilitate the (sustainable) functioning of the eco-system, its stakeholders and the end users in as many ways possible. One of the most important elements therein in to support or facilitate the C-ITS services to become financial and economic sustainability. Financial and economic sustainability refers to the ability of the service to operate and generate revenue in a self-sufficient manner over the long term while providing economic benefits to the stakeholders involved. Or, in short, without financial and economic sustainability,

the C-ITS service will not survive, and therefor also no longer be available to the eco-system, stakeholders and end users.

Financial sustainability focuses on the financial viability and profitability of the C-ITS service. It involves ensuring that the service's revenue streams are sufficient to cover its operational costs, maintenance expenses, and potentially fund future expansions or upgrades. As such, it requires careful cost management, efficient resource allocation, and a sustainable business model that aligns revenue generation with the value provided by the service.

Economic sustainability looks at the broader economic impact of the C-ITS service. It considers how the service contributes to the overall economy by creating jobs, fostering innovation, and enabling for example more efficient transportation systems. Economic sustainability involves analysing the cost-benefit ratio of the service, evaluating its impact on productivity, congestion reduction, fuel consumption, emissions, and safety. Ideally, a C-ITS product or service should deliver economic benefits that outweigh its costs and have a positive impact on society as a whole.

How can financial and economic sustainability be supported?

The most straightforward parameters that need to be checked or controlled, and for which balanced responses need to be found are:

- User Demand and Value: the service should address the needs of its users and provide tangible value, such as improved traffic flow, reduced travel time, enhanced safety, and convenience. Understanding the target audience and tailoring the service accordingly is crucial to attracting users and generating sustained demand.
- Funding Mechanisms: identifying appropriate funding mechanisms is essential for financial sustainability. This can include a combination of public and private funding, grants, user fees, partnerships with stakeholders, or even ad-supported models. Diversifying revenue sources can reduce dependency on a single funding stream.
- Scalability and Cost Efficiency: designing the C-ITS service to be scalable and cost-effective is important for long-term sustainability. This involves utilizing existing infrastructure and technology where possible, optimizing resource allocation, and adopting scalable architectures and platforms that can accommodate future growth without incurring excessive costs.
- Regulatory and Policy Support: favourable regulatory and policy frameworks play a crucial role in supporting the financial and economic sustainability of C-ITS services. Governments and transportation authorities should create an enabling environment by providing incentives, promoting interoperability, and ensuring fair competition.
- Business Collaboration: collaboration among different stakeholders, such as government agencies, technology providers, vehicle manufacturers, and transportation operators, can contribute to financial and economic sustainability. Partnerships and cooperative arrangements allow for cost sharing, knowledge exchange, and leveraging complementary expertise to achieve common goals.
- End user reimbursement models: to build engagement from end users with C-ITS services, reimbursement models can be implemented to incentivize and encourage end users to adopt and actively participate in these services.

Questions for PAPI

For this PAPI, we look into one specific type of C-ITS services for which you have significant experience. If possible, select one of the following types of C-ITS services:

- Road user warning systems: C-ITS services that focus on providing vehicle drivers with safety-related warnings and information to help reduce accident risk.
- Road user navigation services: C-ITS services that focus on providing vehicle drivers with relevant navigation information in order to help provide a better routing based on local properties (i.e. road access, etc.), contextual properties (i.e. congestion, local road closures due to short-term or long-term events, etc.), or external properties (i.e. meteorological issues, tolling, etc.).
- Road use / mobility management: C-ITS services that focus on assisting road authorities in providing a good usage of available infrastructure for different types of passenger and goods transport (i.e. supporting logistics, passenger transport, goods management, etc.). This can include traffic management, tolling, road infrastructure technology such as traffic lights, etc.
- Other: …

Please describe the service that you've chosen as follows:

- Objective: the C-ITS service is meant to ...
- Target audience: the C-ITS service provides information to …
- Functional and technical requirements: to achieve the C-ITS service, it needs to meet …
- Data requirements: to support the C-ITS service, data needs to meet …
- Active region: the C-ITS service is active in/on …

<u>Question group 1: the eco-system</u>

Do you know the product or service stakeholders?

- Who are the primary / secondary / tertiary stakeholders?
- What are their interests? What is their motivation?
- What role are the looking to pick up (i.e. what is their position in a business model)?
- Are there existing contacts, networks, etc. that are already active? Can you describe these?

Is there an eco-system around the C-ITS product or service?

- Are these stakeholders (assuming you know them) connected with each other?
- What are their relationships (i.e. customer, client, legislator, etc.)?
- Who is responsible for the eco-system? Is it self-reliant or does it require a third party?
- Are there missing links?

What is your role in the eco-system?

- Are you a primary / secondary / tertiary end-user? Note: this can be different for different C-ITS products or services. For some you can be a primary end-user, for some you can be a tertiary end-user.
- Are you a driving force behind the eco-system? If so, how do you do this?
- Are you a member of the eco-system? If so, who is the driving force behind the eco-system? How do you position yourself?

The purpose of asking these questions is to identify, from your perspective, if the investment that you are making in a C-ITS product or service will be supported by an eco-system, or if there is a risk that the product or service perishes as soon as you withdraw your efforts.

Question group 2: the end users

Have you identified the different types of end users?

- Who are these?
- What group of end users are you focusing on? Why is this?
- How large is this group / are these groups? How many of them are you already reaching?

Do you have targets/objectives in relation to the number of end users that you're reaching?

- What are these targets?
- How do you monitor that?
- How do you receive feedback from end users? How do you take their input into account/bring it into practice?
- Do you integrate with existing high-end user number applications (i.e. Waze, etc.)?

What actions to do you take to reach end users?

- What communication actions do you take?
- Do you take specific actions to intrinsically motivate end users to use the C-ITS product or service? (i.e. behavioural change through regular feedback, nudging, gamification, etc.)

Do you have reimbursement models for end users?

- Have you considered reimbursement models?
- Are the reimbursement models, if used, part of the financial and business plan?
- Have you received feedback from end users about possible reimbursement models?

Do you, in some way, inform end users about benefits that they would enjoy from using the C-ITS system?

- Are these realistic (i.e. measurable) benefits?

Question group 3: financial and economic sustainability

Is there a financial plan?

- Is a financial plan in place for the C-ITS product or service?
  - The main purpose of a financial plan is to help determine if a product or service is sustainable. Is such a plan made?
  - If the service/product is already being used, does the plan align with reality?
- Are you responsible for such a plan?

Is there a business plan?

- Is a business plan in place for the C-ITS product or service?
  - The main purpose of a business plan is to provide an overview of the different elements that are required to achieve your goals. In general, for a private company, a business plan is made to support creating revenue, etc. For a public entity, a business plan is made to support creating stability and sustainability. Is such a plan made?
  - If the service/product is already being used, does the plan align with reality?
- Are you responsible for such a plan?

Is the current C-ITS product or service sustainable?

- Is it currently financially sustainable? Why?
- Is it economically sustainable? Why?
- Under what conditions are financial and / or economic sustainability met?
- What challenges were encountered? What solutions were provided/used?
- Who is the main investor (public, private, etc.)?

8.2 Topic 2: Technology choice and integration in operational and functional processes

What is it?

Different types of technology products and services can be used to fulfil a C-ITS requirement. It is even relatively fair to state that for most of the C-ITS services, solutions are available that have evolved from testbed or trial projects and have turned into scaled-up implementation programs or projects. Each (technological) solution comes with specific advantages and disadvantages. It is important to identify these aspects of the solution and make an appropriate choice as to which technology provides a good fit to the C-ITS requirement, as a whole.

Equally important to the actual implementation of the technology solution is the integration of this solution into the working processes with the different (types of) stakeholders. The introduction of a (new) technology into a functioning system often requires existing processes to be slightly altered, personal skills to be trained, responsibilities to be identified, etc.

Why is it important?

The long-term outcome on the effective use of a technology product or service depends on various elements. For example (non-exhaustive): product readiness, cost & pricing, perceived advantages, end user appreciation, etc. One element that is often looked over, or assumed to come automatically if the technology solution fulfils the other criteria, is the integration within existing structures and processes. With the latter, it is meant that the professionals that are providing or using the C-ITS service make use of it within their daily operations and functions. The service itself is a tool to be used by them, and the optimal/sustainable use thereof depends largely on a good integration with their other activities.

Such integration is however very important as it is a facilitator for, for example, follow-up actions, quality control, cost-efficiency optimization, impact maximization, etc. In some extreme cases, it can even be that a perfect product fails because there is no stakeholder to be found where the product is integrated into its operational or functional processes. There is no-one who is responsible for, or willing to actively monitor, follow-up, check, etc. which ultimately results in sub-par usage.

Questions for know-how gap identification (limited PAPI)

We investigate one specific type of C-ITS services for which you have significant experience. If possible, select one of the following types of C-ITS services:

- Road user warning systems: C-ITS services that focus on providing vehicle drivers with safety-related warnings and information to help reduce accident risk.
- Road user navigation services: C-ITS services that focus on providing vehicle drivers with relevant navigation information in order to help provide a better routing based on local properties (i.e. road access, etc.), contextual properties (i.e.

congestion, local road closures due to short-term or long-term events, etc.), or external properties (i.e. meteorological issues, tolling, etc.).

- Road use / mobility management: C-ITS services that focus on assisting road authorities in providing a good usage of available infrastructure for different types of passenger and goods transport (i.e. supporting logistics, passenger transport, goods management, etc.). This can include traffic management, tolling, road infrastructure technology such as traffic lights, etc.
- Other: …

Please describe the service that you've chosen as follows:

- Objective: the C-ITS service is meant to ...
- Target audience: the C-ITS service provides information to …
- Functional and technical requirements: to achieve the C-ITS service, it needs to meet …
- Data requirements: to support the C-ITS service, data needs to meet …
- Active region: the C-ITS service is active in/on …

What is the current technology status?

- Is a suitable technology used to fulfil a C-ITS demand? Has a requirement/solution fit been achieved? (Is it registered?)
- Does a technology gap, compared to the functional and technical requirements present?
- Has a comparison of technologies been made?
- Has a choice been made for specific types of technology (i.e. 5G vs wifi-p)? Why has this been made? What is lacking to make a choice?
- What (technology) issues have been encountered? What solutions are there?
- What is/was the (C-ITS) system roll-out timing? If it has already taken place or is ongoing, is it timely? Are there delays?

Are the current technology solutions future proof?

- Is the current technology functioning sufficiently good, if changes in usage are occurring (also including changes in the number of usages)?
- Is the technology provider functioning good? (i.e. product support, product evolutions, etc.)
- Are there future/upgraded solutions on the horizon/being discussed? What are these? Why would these be considered? (i.e. improved cost-efficiency, improved usability/HMI, etc.)

Is the technology integrated into functional processes?

- What are relevant processes related to the use of the technology?
- Is the technology usage owned by specific stakeholders? Are the C-ITS solutions/services integrated in their operational and/or functional processes? (for example: who does what, who does x when, what are basic conditions that need to be met)
- Do you experience issues with the integration of a C-ITS service into your operational and/or functional processes?
- How is this integration achieved / How could this integration be achieved?
- Has training been provided / Are you looking into training? What types of training? How regular?

- Is the technology accepted (positively) by the people who are using it in their daily operations?

Do you know of specific knowledge/know-how sources outside of MERIDIAN that we can contact to gather relevant information? Can you provide us with contact details?

8.3 Topic 3: Regulation and standardization

What is it?

Several organizations and initiatives are involved in developing regulations and standards for C-ITS. It's worth noting that regulations and standards may vary across different regions and countries. However, efforts are being made to harmonize these standards globally, allowing for seamless interoperability and international deployment of C-ITS services.

Examples of key entities and efforts in this regard are:

- European Union (EU):
  - European Telecommunications Standards Institute (ETSI): ETSI is responsible for developing and maintaining the standards for C-ITS communication, including the ITS-G5 (IEEE 802.11p) and Cellular Vehicle-to-Everything (C-V2X) technologies.
  - European Committee for Standardization (CEN): CEN is involved in developing standards related to the architecture, data exchange, and security aspects of C-ITS.
- International Organizations:
  - International Telecommunication Union (ITU): ITU provides global standards and recommendations for C-ITS communication technologies.
  - ISO/TC 204: ISO/TC 204 is the Technical Committee responsible for developing international standards for Intelligent Transport Systems (ITS), including C-ITS.
- International Initiatives:
  - Car 2 Car Communication Consortium (C2C-CC): C2C-CC is an industry-led consortium that focuses on the development and promotion of C-ITS communication standards and interoperability.
  - European C-ITS Deployment Platform (EIP): EIP brought together public and private stakeholders to support the deployment of C-ITS services in Europe and facilitate the development of harmonized standards.

These organizations and initiatives work collaboratively to define technical standards, communication protocols, security measures, and interoperability guidelines for C-ITS. The standards cover areas such as vehicle-to-vehicle (V2V) communication, vehicle-to-infrastructure (V2I) communication, data exchange formats, cybersecurity, privacy protection, and service provision.

Why is it important?

The regulation and standardization of C-ITS services are essential to ensure interoperability, safety, and efficient deployment of these services across different regions and countries.

Questions for know-how gap identification (limited PAPI)

We investigate one specific type of C-ITS services for which you have significant experience. If possible, select one of the following types of C-ITS services:

- Road user warning systems: C-ITS services that focus on providing vehicle drivers with safety-related warnings and information to help reduce accident risk.
- Road user navigation services: C-ITS services that focus on providing vehicle drivers with relevant navigation information in order to help provide a better routing based on local properties (i.e. road access, etc.), contextual properties (i.e. congestion, local road closures due to short-term or long-term events, etc.), or external properties (i.e. meteorological issues, tolling, etc.).
- Road use / mobility management: C-ITS services that focus on assisting road authorities in providing a good usage of available infrastructure for different types of passenger and goods transport (i.e. supporting logistics, passenger transport, goods management, etc.). This can include traffic management, tolling, road infrastructure technology such as traffic lights, etc.
- Other: …

Please describe the service that you've chosen as follows:

- Objective: the C-ITS service is meant to ...
- Target audience: the C-ITS service provides information to …
- Functional and technical requirements: to achieve the C-ITS service, it needs to meet …
- Data requirements: to support the C-ITS service, data needs to meet …
- Active region: the C-ITS service is active in/on …

What are issues that you encountered for which you believe regulation and/or standardization would be a solution?

- How are you dealing with these?
- Have you considered / tried alternatives to regulation/standardization actions to solve such issues? If yes, how. If no, why have they not worked?

What benefits / advantages have you identified for C-ITS services for which regulation and/or standardization actions would be required?

What drawbacks / disadvantages have you identified for C-ITS services for which regulation and/or standardization actions would be required?

Do you know of specific knowledge/know-how sources outside of MERIDIAN that we can contact to gather relevant information? Can you provide us with contact details?

9 PAPI analysis

For this chapter, we focus on the outcome of the PAPI interviews which were conducted with the following Meridian partners:

- Landesbaudirektion Bayern (Germany)
- Agentschap Wegen en Verkeer (Belgium)
- Autorità di Sistema Portuale del Mar Tirreno Settentrionale (Italy)
- Die Autobahn GmbH (Germany)
- Autostrada del Brennero SpA (Italy)
- Transport Infrastructure Ireland (Ireland).

9.1 Topic 1: Eco-system and end users: importance, financial and economic sustainability and facilitation

The overall topic definition

- The general indication is that the proposed outline of the topic is accepted by the respondents. Comments on elements of the definition were received and integrated in the output from the different question groups.

Question group 1: the eco-system

- The overall understanding of what makes an eco-system and how it may function is high. A number of remarks are given which are relevant to all parties:
  - The actors in an eco-system can be very variable. Both in terms of type, number as well as functioning. This depends on various elements:
    - the type of (C-ITS) service or application which is being discussed
    - the purpose of the (C-ITS) service or application
    - the relation between the different actors (user-owner, payer-procurer, co-development, etc.)
    - the overall setting (R&D project, roll-out project, overarching program, roll-out activity, etc.)
  - The overall functioning of eco-system
    - An eco-system may be competitive as well as cooperative.
    - The necessity for the presence of an eco-system is accepted, but the framework wherein an eco-system works can be very variable. This means for example that it may be very difficult to come to general agreements that make for a long-lived eco-system. It also makes for (slow or fast) changing eco-systems over time.
    - Most of the eco-systems that were used as an example are the result of a project-based functioning, rather than a program-based functioning or a product-based functioning. A project-based functioning has a set of clearly defined roles and functions (i.e. a party that asks and a party that delivers). This is different from program-based functioning where a more long-term relationship is sought for, or a product-based functioning where the product-owner aims to have a long-life product.

Remark: an eco-system can only develop once the standards which are required for large scale tendering of roadside and implementation of vehicular components are in place.

- Particular interest in the changing nature of eco-systems
  - An eco-system is not a rigid structure. It has the capability to change, for example when new stakeholders turn up with different solutions or products. An example is that product offered by parties such as Waze and Google maps, which may be very good at what they offer, up to the point where the primary end-user is more attracted to that solution, even if it is "in conflict" with other offerings.

- **There is a distinction however between a general understanding of the eco-system and its function on one hand and the effective creation or implementation of such an eco-system in practice.**
  - Some of the respondents indicated that the eco-system is currently not within the scope of the project, or that it falls outside of the responsibilities of the actors involved in the project. Albeit those actors would all be part of a fully-fledged eco-system.
  - This is of some significance as there is a real risk that a (well-functioning) service may yet come to a decline if no real functioning eco-system is active, and as a result thereof, the business and financial plans are not elaborated. In these cases, the financial and economic sustainability of a service comes under pressure.
  - Similarly, the eco-system and the C-ITS services may come under pressure if the relations towards the primary stakeholders (usually the end users) are not explicitly covered, for example within a business plan. A voluntary pickup of the use of a service poses a high risk as (1) it is very much depending on externally controlled factors for end users to experience the service (including "communication about the service", "the integration of the service in end-user applications", but leading all the way up to "loosing end-users to more attractive providers").
  - **As such, this is identified not as a knowledge gap, but as a gap in the field of practice which may have occurred as a result of insufficient opportunities prior to the project to create an eco-system or as a result of insufficient opportunities to persuade third parties to engage in an eco-system.**
  - This is an interesting gap to further investigate within MERIDIAN.
  - Public authorities have a business plan as they are obliged to support increased traffic safety. With basic infrastructure in place because of this, the technology needs to be implemented in vehicles. Applications should be able to draw on this infrastructure, so investments could be minimal for a specific purpose if the (then) available hardware is sufficiently open to support multiple business cases apart from prioritisation of emergency vehicles and traffic safety (which are paid for by public budget). Lacking are only the standards for formats, transmission technology (ITS G5 vs. 5G) and PKI (Public Key Infrastructure).

The C-ITS services that were used for this knowledge basis by and large serve the purpose to perform an optimisation or information service for a road user. The road user is either a private driver (car driver) or professional driver (professional vehicle such as HGV). These actors were correctly identified.

A clear distinction was made in terms of the impact area of the C-ITS services that were used for this knowledge basis:

- A spread exists ranging from projects that aim at identifying best technologies or consolidate earlier findings in relation to a limited number of C-ITS services, up to large-scale full program roll-out of a wide range of C-ITS services.
- Insofar that the respondents represent projects that have a clear innovation and development objective, a number of limited insights do not need to be critical. However, an improved understanding of, for example, the eco-system, the reasons why end-users would consider a C-ITS service, a reimbursement model, etc. may help the development of the service from an innovation and development project into a roll-out program.

The identified (service) stakeholders are known to the respondents. This is an important step towards identifying the eco-system and its actors. A short overview of the different types of stakeholders will be presented in the final analysis. These include:

- Primary stakeholders
  - o Private road users
  - o Public transport
  - o Professional transport drivers and logistic companies
  - o Traffic centers
  - o Emergency services / Emergency service centers
  - o Roadside services
  - o Public authorities /road authorities
- Secondary stakeholders
  - o OEM
  - o Service providers
  - o Telecommunications providers (network operators)
- Tertiary stakeholders
  - o Vehicle and goods insurance companies
  - o Research & Development companies, institutes, universities, etc.
  - o OEM suppliers
  - o Service suppliers (incl. banks)
  - o Sensor suppliers
  - o Data-related companies (incl. Statistics), data owners/data providers
  - o Data users
  - o Services supporting public authorities.

<u>Question group 2: the end users</u>

Two main groups of end users were identified by the different respondents. Overall, the respondents had a good understanding of these groups for their projects and what they are expecting. This is summarized below:

- Front-end end users (a.k.a. “boots on the ground”). These are the actors that drive around and are assisted by C-ITS services during the various parts of the execution of road trips: planning, routing, execution.
  - o Vehicles (with a level of automation)
  - o Human user of vehicles
    - Private vehicles, both motorized and non-motorized.
    - Professional vehicles, both heavy and light goods vehicles, taxi services, etc.
    - Emergency vehicles, including emergency services (police, fire services, ambulances, etc.) and supporting vehicles (towing services, road-side assistance, etc.)
    - Public transport, including “road based” as well as “rail based” public transport.
- Back-end end users (a.k.a. “(everyone associated to) the service provider”). These are the actors that enable or facilitate the actors that driver around. Mostly, they deal with the infrastructure (the effective use of the infrastructure, maintenance, etc.) or the rolling material usage.
  - o Traffic centres
  - o Road authorities
  - o Logistics companies
  - o Emergency service centres
  - o Data owners/data providers
  - o Data users
  - o This may include public authorities whose function aligns with the traffic centers or road authorities.

However, for both groups, there were only limited pathways presented towards the effective integration into an active eco-system (none of which were fully implemented). This was expressed in several ways:

- An understanding of the detailed requirements that (front-end or back-end users) would pose on a C-ITS service was not always present (except for those requirements where the respondents fulfilled one of the end user roles themselves). From a product or service perspective this is a high risk, as it may be possible that services are developed that are not in line with end-user expectations.
- The absence of detailed forms of renumeration or reimbursement model (based on or within an eco-system) is a high risk towards the longevity of a product of service. Neither monetary nor non-monetary reimbursement models are actively implemented. This includes the absence of communication about advantages/disadvantages on the use of the system towards front-end as well as back-end end users. As such, both front-end as well as back-end end users may simply not know of C-ITS services or have subpar interest in them, and therefor also not use them.
- Limitations on monitoring and evaluation practices is a high risk towards the implementation of C-ITS services or products. The impacts that C-ITS services have on the front-end as well as back-end end users is a potentially important argument towards reaching these end users. This includes a limited view on the impacts on daily operations and the integration of services in daily activities.

<u>Question group 3: financial and economic sustainability</u>

For none of the respondents, a financial plan was in place where the different stakeholders from an eco-system were integrated. If a financial flow was described (as part of a non-formal plan), this hinged on the presence of public funds to provide the necessary components to, or a full C-ITS service.

There were strong limitations to the know-how on the possible or expected impacts that the implementation of C-ITS services or products would have on both front-end as well as back-end end users.

As a result, there is a strong risk that both the monetary as well as the non-monetary costs and benefits on the use of a C-ITS service or product is unclear. At the same time, this also means that there may not be a strong enough ground for primary, secondary or tertiary stakeholders to engage in a (financial and/or economic) sustainable plan.

9.2 Topic 2: Technology choice and integration in operational and functional processes

The overall topic definition

- The general indication is that the proposed outline of the topic is accepted by the respondents.
- By and large, the technology choice to be made is between short-range (Wifi-P) and long-range (cellular) technologies.

General analysis related to technology

- The different respondents answers could be split into two groups
  - o R&D projects.
  - o Roll-out projects or programs.
- R&D projects
  - o The technology choice in these projects is based on local necessity and experience from previous projects. As the purpose for this type of projects is mostly to identify the suitability of a possibly solution or to develop such a solution, the outcome is important for future roll-out actions. However, at the current time, the outcome of the choice or development process is not yet clear.
- Roll-out projects or programs
  - o The overall consensus on a choice for different (types of) technologies, either an outright choice for one type of technology or a combination of technologies, is that this is very much situational dependent.
  - o Situational factors that may influence this choice are:
    - Existing technology uses (usually from previous projects): if existing technology is proving to be sufficient, there may be no need to consider alternatives.
    - Geographical or meteorological limitations
    - Financial limitations (or possibilities to make use of parallel technologies)
    - Expected outcomes towards end-user pick-up and/or system integration
    - Public stakeholder engagement or decision-making which is not under control of the project or program.

General analysis related to the integration within functional or operational processes

This topic was, in general, not touched upon by the respondents.

In the case of R&D projects, this is not abnormal as these are still in the process of identifying or developing suitable C-ITS solutions. Nevertheless, taking into consideration the integration into the functional or operational processes of the so-called back-end end users who offer support to the C-ITS services, is an important step towards developing or choosing for specific C-ITS solutions.

In the case of roll-out projects or programs, this is even more important as the purpose of such projects or programs is to ensure a long-term functioning C-ITS system.

9.3 Topic 3: Regulation and standardization

This topic was identified as being potentially double work with work already done in other organisations. It is considered more valuable to shift the knowledge building activities around regulation and standardisation towards collecting and spreading information from actions directly aimed at gaining such knowledge. E.g. from the C-Roads or C-Roads Extended platform.

10 Workshop 30 November 2023 – Execution & Round 2

10.1 Agenda

MERIDIAN C-ITS workshop
Date: 30th of November 2023: 9h00 – 12h00

Time	Agenda Item	Lead/Speaker	Supporting Documents
9h00	Welcome & Introduction	Jean	
9h10	Outcome of the PAPI interviews	Lars	
9h40	Interactive feedback on PAPI interviews	All partners	
10h00	Topics for further in-depth knowledge building (questionnaire) 10min per partner	Lars/All partners	
11h50	Next steps AOB		
12h00	*End*		

In order to support the MERIDIAN partners, it was decided to bring them again together for a (on-line) workshop where a bridge between knowledge (know-how) and practice was offered. The main outcomes of the PAPI were presented and discussed, and in the main body of the workshop, the MERIDIAN partners were invited to work on the hypothesis that their services had left the developmental or testing phase and were now going into a full roll-out program. In this way, the workshop participants could already gain insight and take some practical (initial) actions to implement their knowledge into a field activity.

The workshop presented the findings from the analysis of earlier interactions before moving to the second round.

10.2 Outcome of the PAPI interviews

One of the most important outcomes of the PAPI was the finding that the key participants do have a high level of know-how already about different aspects that are important for the implementation of sustainable C-ITS services. An improved understanding of these aspects is, in part, the result of the current Knowledge Building task. By itself, this is already a positive outcome for any knowledge-building activity.

However, one important element did become apparent as a result of the analysis of the PAPI, and that is that the effective operationalization (i.e. bringing this knowledge into practice) was sub-optimal. In part, this could be explained by the status of the different C-ITS services which were discussed with the different partners: a large number of services are currently still in a development phase, or are being tried and tested in relatively small projects. In other words, only a minority of project partners were active in large-scale roll-out activities.

10.3 Round 2 – Additional Questionnaire

Four MERIDIAN partners actively participated in this session:

- Transport Infrastructure Ireland
- Flemish Agency for Roads and Traffic
- Die Autobahn
- Autostrada del Brennero.

As we extended the workshop beyond MERIDIAN partners such as the VIKING Group, input was also provided by the Swedish Transport Administration.

Round 2 of the workshop was built around 3 questions to challenge participants into looking into the future, and dealing with the most important challenges:

- To have a healthy eco-system: which parties/stakeholders (name) do you at least need to bring the C-ITS services to the general public?
- To find your end-users: as a provider of a C-ITS service, how will you find out, or make sure that your service will be used by the intended end users?
- To obtain financial sustainability: what results must be achieved (at least) to maintain sufficient momentum for a healthy financial/economic sustainable situation?

10.3.1 Stakeholders / Eco-system

Question: to have a healthy eco-system: which parties/stakeholders (name) do you at least need to bring the C-ITS services to the general public?

The ideas where not that unanimous among the participants, and highly depending on the use case that was considered for the analysis (e.g. road works warning or other).

Primary stakeholders
Private road users organisations
Public transport operators
Professional transport drivers and logistics companies
Traffic centres
Emergency services / emergency service centres
Roadside services
Public authorities / Road authorities

Even for primary stakeholders, depending for the envisaged use case, not all of the listed primary stakeholders were seen as strictly required to bring that particular C-ITS service to the public. Certainly they are part of the C-ITS ecosystem. The most common are Traffic Centres and the public/road authorities, as well as public transport operators, logistic companies, emergency

services and roadside services (such as road cleaning / maintenance companies, towing companies, and the like).

Secondary stakeholders
OEMs
Service providers
Telecommunications providers (network operators)

In general the view on the listed secondary stakeholders was more or less unanimous, both OEMs and Service providers were considered required. Except for telecommunications services providers, which were considered by some as a required commodity.

Tertiary stakeholders
Vehicle and goods insurance companies
R&D companies/institutes/universities/etc.
OEM suppliers / sensor suppliers
Service suppliers (incl. banks)
Data-related companies (incl. statistics), data owners/data providers
Data users
Service providers supporting public authorities

For the listed tertiary stakeholders the views were very diverging, and two were considered important: data-related companies (incl. statistics) / data owners / data providers and service providers supporting public authorities.

10.3.2 Assure C-ITS service usage by end users

Question: to find your end-users: as a provider of a C-ITS service, how will you find out, or make sure that your service will be used by the intended end users?

Because of the phrasing of this question, different results were obtained:
a) how to find out:

- end user questionnaires
- monitoring and evaluation of the system
- monitor the number of CAMs along the route by receiving DENMs from end users
- monitor the progress of the car along the route to determine the correlation between the C-ITS event and the driving behaviour
- monitoring improvement of traffic flows, reduction of accidents, pollution reduction
- need the statistics (from the OEMs) and perform data analytics
- there might be a potential using AI to see patterns in the transport system;

and b) how to or make sure:

- what's in for the end user

- user experience
- rewarding and gamification
- extra easy and carefree add-ons
- integrated in what they are used to
- introduction of laws in that force OEMs to implement the technical requirements
- European regulations and guidelines
- constant exchange of knowledge with OEMs
- explanation of the benefits of the service.

10.3.3 Financial sustainability

Question: to obtain financial sustainability: what results must be achieved (at least) to maintain sufficient momentum for a healthy financial/economic sustainable situation?

The answers to this question were centred around:

- societal benefits justify or require (recurrent) public investment
- economic or financial sustainability is difficult to measure directly, and is currently not our goal
- expected results are to be found in:
    - improvement of road safety
    - travel time reduction
    - congestion alleviation
    - reliable information dissemination to road users
    - end user satisfaction
- service needs to be free of charge
- metrics will be needed that will show the effect in the transport system based on digital services for connected vehicles.

11 Conclusions

The participants in the various knowledge building workshops presented their C-ITS projects and exchanged their insights. Furthermore, the participants selected 3 topics for PAPI interviews that were explored further in depth. These 3 PAPI topics explored were:

- eco-system and end users: importance, financial and economic sustainability and facilitation,
- technology choices and integration in the operational and functional processes,
- regulation and standardization.

The key takeaway of the PAPI interviews was the finding that participants already have a high level of knowledge about the different aspects that are important for the implementation of sustainable C-ITS services.

A better understanding of these aspects is partly the result of this knowledge building task, which is already a positive outcome for any knowledge building activity.

However, one important element did emerge from the analysis of the PAPI, and that is that the effective operationalization (i.e. putting this knowledge into practice) was not optimal. This could partly be explained by the stage of the different C-ITS services discussed with the different Meridian partners: a large number of services are currently still in a development phase, or are being trialed in relatively small projects. In other words, only a minority of project partners were active in large-scale rollout activities.

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