Conférence Européenne
des Directeurs des Routes
Conference of European
Directors of Roads

Association Européenne des Concessionnaires
d'Autoroutes et d'Ouvrages à Péage

Project Report

CEDR / ASECAP

Intelligent Transport Systems for Safe, Green and Efficient Traffic on the European Road Network

Findings from the European ITS Platform

March 2022

Project Report

CEDR and ASECAP

Intelligent Transport Systems for Safe, Green and Efficient Traffic on the European Road Network

Findings from the European ITS Platform

Editors:
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Picture frontpage: Rijkswaterstaat

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CEDR Project Report 2022-01

Intelligent Transport Systems for Safe, Green and Efficient Traffic on the European Road Network

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1 Foreword by CEDR and ASECAP

The recent Pandemic has emphasised the importance of a sustainable and efficient road infrastructure. The European Road network is a fundamental part of European society and the backbone for the movement of goods and people around Europe and represents 75 % share of transport modes. Road operators have shown the resilience of roads in providing continuity of services mainly the delivery of goods for medical care, to provide foods for the citizens ….

Safety, environment and efficiency remain the cornerstones of the day-to-day activities of road operators across Europe. Both public and private sector road operators address the sometimes conflicting challenges. Working to ensure that people travel safely, business goods arrive at the right time, that people and nature are not adversely affected by road transport and that the trust invested by the public for the care of our infrastructure is justified.

For many road operators, the role of digitalisation in addressing these challenges has a clear focus by enhancing traffic management. The development of the technological solutions to drive forward the road safety, environment and efficiency agenda has been a major objective of the EU EIP. This major shared European project has combined the talents of experts from the membership of CEDR and ASECAP together with others from across the sector. They have worked diligently to develop and trial the practises to provide harmonised real time travel information services for European Citizens who can benefit from them equally. They can be seen presented in these important guidelines. Technology alone is not enough of course and need to be supplemented by the skills development of the entire sector.

The entire road sector is aware of the responsibly that it has to provide sustainable mobility and to be able to make proper traffic management plan when facing climate change impacts (flood, heavy snow….). As the sector that takes on the major burden of European transport needs, roads do need to take on-board all the tricks that can make it even more sustainable. It is worth noting that the unique role that roads play in supporting all of the 17 Sustainable Development Goals of the United Nations From addressing inequalities and poverty, supporting economic development and protecting the environment on land, sea and air, roads provide that reliable and resilient foundation for the benefit of peoples across Europe. Important sustainability objectives, such as those in the complementary EU strategies echoing the SDGs include our shared vision zero for road safety alongside our environmental objectives such as on decarbonisation - to reduce GHG emissions by 90% by 2050 – and on circularity.

This publication of the outcomes of the six-year EU EIP project provide us shared guidelines with a springboard for further digitisation of our safe and modern society. One of the key observations for the future is that the road cannot be considered separate from the functionalities of the vehicles. Moreover, we can no longer continue to treat our telecoms (and energy) networks as separate entities. In the spirit of the EU EIP, it is important that we continue to strengthen cooperation between all stakeholders that support decarbonised mobility solutions – or indeed sometimes - as we have experienced over the last two years - those that replace mobility with alternative means of connectivity.

We thank all those involved in bringing EU EIP to its successful conclusion and look forward to taking the next steps in this exciting collaborative venture.

CEDR	ASECAP
Steve Phillips	Malika Seddi
Secretary-General CEDR	Secretary-General and CEO

2 Introduction

Authors: Roberto Arditi, Marco Garozzo (SINA)

2.1 Why this book

The European ITS Platform is an action proposed by 15 Member States and co-funded by European Institutions within the frame of the Connecting Europe Facility. This book represents a short overview of the many results achieved in that action.

The European primary road network is, as far as the European citizens are concerned, a unique physical layer on which European citizens base, indirectly or directly, their daily lives. Commuting, specific trips and goods' transport take place on the network that is the facility for the European transport multi-modal network as a whole. Further to being segmented in national networks, a segmentation in terms of operation is also present. National road authorities, as well as road operators are in charge of operating the roads, and a multiplicity of actors can be active at a national level.

Experts of the European ITS Platform collated best practices, case studies and achieved results that are considered important for the operation and evolution of the European road network. On the other hand, CEDR and ASECAP represent together the totality of the operation of the core, comprehensive network and beyond. This is the reason why the leadership of the European ITS decided to consult both ASECAP and CEDR officials on results achieved.

Within the frame of this cooperation CEDR, together with ASECAP, proposed to host this book within the frame of CEDR series of technical books. The project management of the European ITS Platform is deeply grateful to CEDR, ASECAP and to experts of the Communication Team, who efficiently coordinated the publication of this book.

2.2 Strategic framework - Climate

Mankind is facing a climate countdown. Science tells European and global policymakers that the global heating has to be limited to 1.5 degrees Celsius above pre-industrial levels. Our planet is on track for a three degree rise at least. Important parts of the European territory have been overpassing already the 1.5 degrees threshold.

We all know it by now: billions of people around the World are already suffering from this situation and this is just the beginning. Climate disruption, due to our outdated use of fossil fuels, is causing unprecedented wildfires, more intense and frequent cyclones, floods, droughts and other weather extremes. Toxic air pollution is choking our major cities and harming our health, biodiversity on land and sea is declining. In the summer of 2021 multiple wildfires burnt dozens of homes in Greece, after an historic heatwave. People have died after record-breaking rainfall flooded underground railway tunnels in China, leaving passengers trapped in rising waters. The July 2021 rainfall over Europe triggered flooding that swept away houses and power lines, and left more than 200 people dead, mostly in Germany. Dozens died in Belgium and thousands were also forced to flee their homes in the Netherlands. The press reports that the intensity and scale of the floods in Germany have shocked climate scientists, who did not expect records to be broken this much, over such a wide area, or this soon.

Figure 2.1: Climate change: downed trees in the Italian Alps - aftermath of the "Vaia" storm

European citizens, in an overwhelming majority, consider climate change a very serious problem, impacting themselves and society as a whole. Actions are now needed, demanding to prepare for the future. Europe needs a new growth strategy that transforms the Union into a modern, resource-efficient and competitive economy. This new strategy has not only a moral (and practical) imperative but it can be seen as a prospect to many new jobs created by the transition, the opportunity to make the European industry more competitive and upgrading the key European facilities, including roads.

The European Commission presented the "European Green Deal"[1] – a roadmap for making the EU's economy sustainable by turning climate and environmental challenges into opportunities across all policy areas and making the transition just and inclusive for all. The European Green Deal considers digital technologies as a critical enabler for achieving the sustainability goals in many different sectors, including transport[2].

2.3 Strategic framework – Road Safety

Road Safety is a major societal issue. Each year, the equivalent of a medium-sized town dies on the roads of the European Union. Consequently, safety related benefits are top priority for the European community among other societal benefits. Digitalisation programs, concretely (and cost-efficiently), contribute to the European goals for safety.

European roads are the World's safest and road fatalities have greatly reduced in recent decades. Nevertheless, the number of deaths is still unacceptably high, and progress has slowed in recent years. Therefore, the EU has adopted the Vision Zero and Safe System approach to eliminate deaths and serious injuries on European roads. This approach reframes road safety policy by focussing on the prevention of deaths and serious injuries.

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[1] The European Green Deal - Communication from the Commission to the European Parliament, the European Council, the council, the European Economic and Social Committee and the Committee of the Regions - COM/2019/640 final

[2] Europe on the Move - Sustainable Mobility for Europe: safe, connected, and clean - Communication from the Commission to the European Parliament, the European Council, the council, the European Economic and Social Committee and the Committee of the Regions - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0293

For the next decade, the EU has set in the EU road safety policy framework 2021-2030[3] a new 50% reduction target for deaths and, for the first time, also for serious injuries by 2030. The Stockholm Declaration of February 2020 paves the way for further global political commitment for the next decade.

Figure 2.2: Training on Italian motorways to improve road safety

The external cost of road crashes has been estimated to be around 280 billion euros, or around 2% of EU GDP. The Commission's Strategic Action Plan on Road Safety and EU road safety policy framework 2021-2030 also set out ambitious road safety plans to reach zero road deaths by 2050 ('Vision Zero').

To reach “Vision Zero” the Commission is implementing the Safe System in the EU. This Safe System requires safer vehicles, safer infrastructure, better use of protective equipment, lower speeds and better post-crash care. Major investments are now being devoted to developing connected and automated vehicles and their interaction with other road users and with the digital and physical road infrastructure. An EU strategy on connected and automated mobility[4] was adopted as part of the “third Mobility Package”.

2.4 Strategic framework - Digitalization

Transport and roads are requested to contribute to this process. Digitalization has the potential to contribute significantly to the objectives of common European interest including a green, safe, smarter, less congested and sustainable mobility. European and National Authorities encourage the development of an integrated transport system and a better use of the existing infrastructures, increasing this way the efficiency of the TEN-T Road Network and relevant traffic Corridors.

The European Commission has defined significant pillars upon which all sectors will be further developed in the years to come: Europe Fit for the Digital Age[5] is also at the centre of the

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[3] Next steps towards ‘Vision Zero’ EU Road Safety Policy Framework 2021 - 2030 - Commission Staff Working Document: - https://op.europa.eu/nl/publication-detail/-/publication/d7ee4b58-4bc5-11ea-8aa5-01aa75ed71a1

[4] On the road to automated mobility: An EU strategy for mobility of the future - Communication from the Commission to the European Parliament, the European Council, the council, the European Economic and Social Committee and the Committee of the Regions - COM/2018/283 final

[5] A Europe fit for the digital age - Empowering people with a new generation of technologies - Commission priorities for 2019-24

political attention and offers to European officials and operators a policy framework to continue developing and deploying ITS throughout the European Union.

On December 9th 2020[6] the Commission approved a new white paper on “sustainable and smart mobility strategy”, replacing the white paper on transport of 2011. This is one of key documents on the way forward of Europe. The white paper also includes a list of potential projects to be implemented and flagship projects to show the way ahead to the public.

Figure 2.3: Traffic control centres: the backbone of digitalization for the infrastructure

The ITS Directive 2010/40/EU[7] was adopted by the European Union on 7 July 2010, to accelerate the deployment of the ITS across Europe. The directive has laid the foundation to ensure that deployments on the four priority areas identified (optimal use of road - traffic and travel data, continuity of traffic and freight management ITS services, ITS road safety and security applications, linking the vehicle with the transport infrastructure) step forward efficiently and in a coordinated way.

Currently European Institutions are working on the revision of the ITS directive, and the delegated regulations attached to it, on real-time traffic information services and on multimodal travel information services[8]. The revised directive is expected to broaden the scope of ruled activities: real-time traffic information will be key in enabling enhanced traffic management and mobility management functionalities, which more and more stakeholders are now looking at with increased interest. This approach will not only require new technologies, but also new approaches allowing the transformation of the mobility sector to contribute to the Green Deal objectives that are expected to be part of the new directive. That is why the European

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[6] Sustainable and Smart Mobility Strategy clean putting European transport on track for the future - Communication from the Commission to the European Parliament, the European Council, the council, the European Economic and Social Committee and the Committee of the Regions – COM/2020/789 final

[7] Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport Text with EEA relevance - COD 2008/0263

[8] Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2010/40/EU on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport - COM/2021/813 final

Commission, together with the Member States, are planning to add new data types and to extend the geographical scope of the relevant delegated regulation on real-time traffic information services. This way, digitalization has the opportunity to play an important role in fostering multimodality, allowing safer, more sustainable and efficient travel based on real-time information.

2.5 The European ITS Platform

Services enabled by Intelligent Transport Systems positively impact road congestion, safety and contribute to the safeguarding of the environment. The progressive widening of their deployment contributes to innovation on the Trans European Road Network. Furthermore, advanced services contribute to the process of digitalisation of transport. In response to proven benefits, Member States, with the support of the EU, amongst others via the Connecting Europe Facility (CEF), have invested billions in ITS over two decades, improving road safety and enhancing the efficiency of the road network. Five trans-European CEF ITS corridors, consistent with the Core and Comprehensive networks, have been established to implement ITS and achieve benefits arising from their deployment. However, maximizing benefits can be put at risk by fragmented approaches and solutions. In order to address this challenge, accompanying the European legislation and implementation of ITS, the European Commission under the CEF program, has, in addition, provided financial support to the European ITS Platform[9] to foster cooperation and promote a harmonised approach between Member States, road authorities, road operators and partners from the private and public sectors. This support encourages acceleration and optimization of ITS deployment in Europe. And it is essential in helping to ensure that European travellers enjoy the benefits arising from seamless ITS services across Europe. The European ITS platform facilitates the establishment of a common approach to deployment of state of the art ITS and promotes the use of EU guidelines and best practices to promote a harmonised European transport network, and interoperable mobility services. The challenges arising from the digitalisation of transport, connected and automated driving, the European dimension of services, multimodality (passenger/freight) and Mobility as a Service, will require even closer collaboration. Experts of the European ITS Platform and the ITS corridors are meeting this challenge to accelerate deployment strategies and support new EC mobility policies.

2.5.1 Activities and partners

The European ITS Platform was active in the period 2016 – 2021. The “European ITS Platform” gathered together the majority of the European key players, cooperating to establish an open “forum”, aiming at providing valid contribution for the future strategy and policy recommendation for better development of ITS service along European road Corridors. The following table provides an overview of the partners and countries leading the various activities in the European ITS Platform. Other countries involved are Denmark, Estonia, Greece, Hungary, Ireland, Norway, Portugal, Romania and Spain.

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[9] www.its-platform.eu

Table 2.1: overview of activities/lead partners in the European ITS Platform

Activity	**Lead Partner**	**Country**
Activity 1 – European ITS Platform Governance and Management	Ministry of Infrastructure and sustainable mobility (coordinator) SINA/ASTM (lead partner)	Italy
Activity 2 – Monitoring and Dissemination including ITS Deployment Guidelines	BASt	Germany
Activity 3 – Feasibility study East-West Corridor and first pilot implementation	Rijkswaterstaat	The Netherlands
Sub-Activity 4.1: Determining Quality of European ITS Services	BASt	Germany
Sub-Activity 4.2: Facilitating automated driving	Finnish Transport Agency	Finland
Sub-Activity 4.3: ITS Deployment Road Map Update	Swedish Transport Administration	Sweden
Sub-Activity 4.4: Cooperative ITS Services Deployment Support	BASt	Germany
Sub-Activity 4.5: Liaison and harmonization on interfaces for data exchange	CEREMA	France
Sub-Activity 4.6: Monitoring and Harmonisation of National Access Points	Rijkswaterstaat	The Netherlands
Sub-Activity 4.7: Provision of updates of ITS spatial road data	ERTICO	Belgium
Activity 5 – Evaluation	Department for Transport	United Kingdom

The flexibility of structure of the European ITS Platform on the scope and level of participation gives the possibility to the Member States/Beneficiaries to choose between various activities/sub-activities, with different levels of involvement, acknowledging their different needs and degrees of maturity. The full organizational Governance and Management structure of the European ITS Platform is presented in the following diagram.

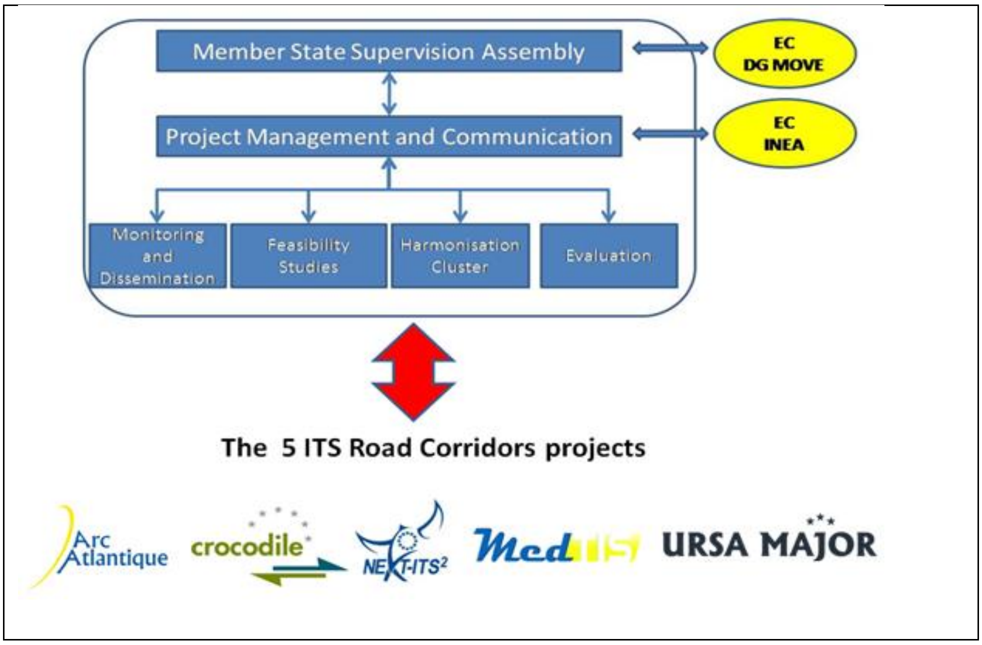


Figure 2.4: Organisational structure of the European ITS Platform

2.5.2 Objectives and scope of the European ITS Platform

The objectives of the EU EIP project can be summarized as follows:

- ensuring sustainable and efficient transport systems in the long run
- promoting an ITS support to the enabling roads jointly to all modes of transport to be efficient, decarbonised
- to support the energy-efficient transport system and technologies
- to optimise road safety
- to improve traffic management
- to optimise the integration and interconnection of transport modes and enhancing the interoperability of transport services
- ensuring the accessibility of transport infrastructures
- contributing to sustainable development and protection of the environment
- development of smart transportation networks

The “European ITS Platform” (EU EIP) is the place where Road Authorities, Road Operators, National Ministries and partners from the private sector cooperate in the field of Intelligent Transport Systems (ITS) for roads. The main goal is to foster, accelerate and optimise current and future ITS deployments on the main road network in Europe in a harmonised way. Almost all EU Member States and neighbouring countries are involved.

To increase the efficiency of the TEN-T Core Network Corridors, it is mandatory to encourage the development of an integrated trans-European network and a better use of the existing infrastructures by employing ITS as well as uniform technical standards. Interoperability must be discussed, designed, tested and finally deployed on the basis of the evolution of technology, standards, specifications and open interfaces. Ensuring continuity of high-quality services for European end-users requires the creation of a proper environment for the harmonization of existing and future ITS Services.

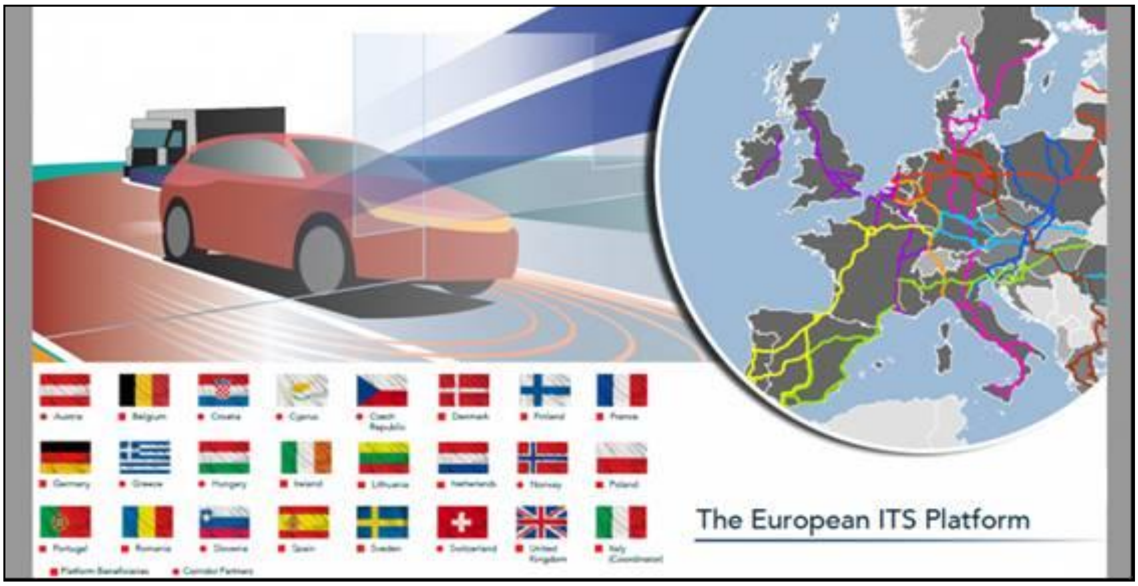
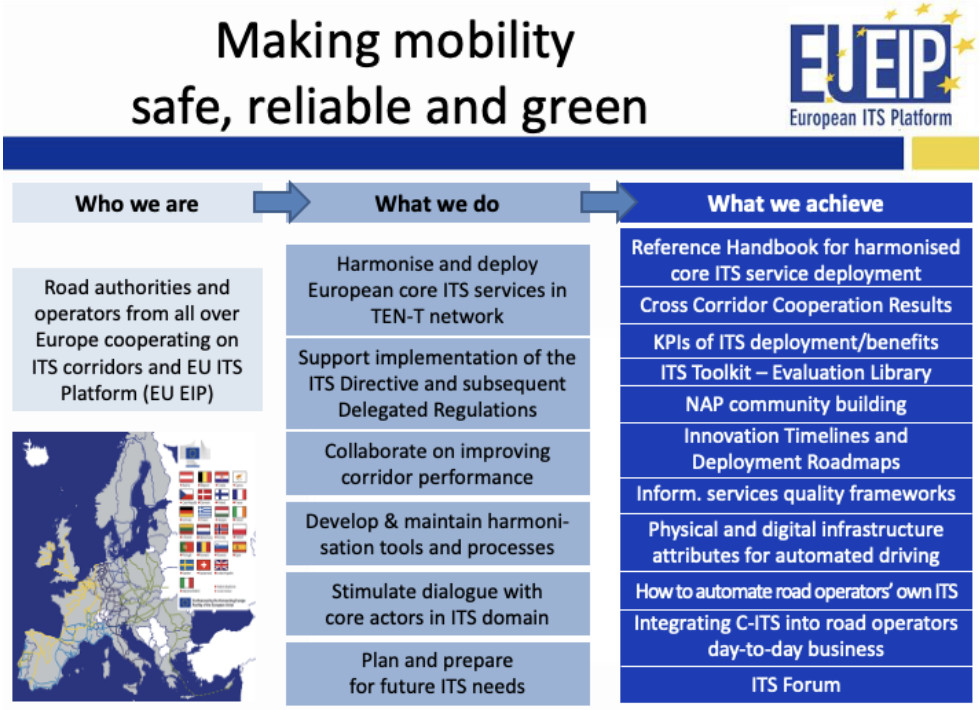


Figure 2.5: Member States and partners of the European ITS Platform

By monitoring, processing, evaluating and disseminating results delivered by the five ITS Road Corridor projects (Arc Atlantique, Crocodile, NEXT-ITS, MedTIS, and URSA MAJOR), each co-funded by the EC within the CEF MAP ITS Call 2014), the European ITS Platform can be considered as the technical European ITS *“Knowledge Management Centre”,* contributing significantly to the most effective use of ITS standards and specifications. The following figure is showing the key scope of the action.



Making mobility
safe, reliable and green

EUEIP
European ITS Platform

Who we are

Road authorities and operators from all over Europe cooperating on ITS corridors and EU ITS Platform (EU EIP)

What we do

- Harmonise and deploy European core ITS services in TEN-T network
- Support implementation of the ITS Directive and subsequent Delegated Regulations
- Collaborate on improving corridor performance
- Develop & maintain harmonisation tools and processes
- Stimulate dialogue with core actors in ITS domain
- Plan and prepare for future ITS needs

What we achieve

- Reference Handbook for harmonised core ITS service deployment
- Cross Corridor Cooperation Results
- KPIs of ITS deployment/benefits
- ITS Toolkit – Evaluation Library
- NAP community building
- Innovation Timelines and Deployment Roadmaps
- Inform. services quality frameworks
- Physical and digital infrastructure attributes for automated driving
- How to automate road operators' own ITS
- Integrating C-ITS into road operators day-to-day business
- ITS Forum

Figure 2.6: Key scope of the EU EIP project

2.6 Concrete results

Achieving a single transport area in the European Union demands coordinated and concerted effort across all modes and by key actors within Member States. Road transport remains preeminent, and its development must respond to changing demands and needs of users, stakeholders and policy.

Technical and scientific literature, including the European ITS Platform "Evaluation Library" clearly indicates that Intelligent Transport Systems (ITS) and the digital processes behind ITS, delivers significant benefits to road authorities, operators as well as to users and the whole of society. The report on "Digitalisation of road transport in Europe"[10] estimates very important impacts of ITS program co-funded by CEF on the European Network.

Projects such as the European ITS Platform have also contributed to the implementation of the Directive, as data becoming available is (re-)used to support other innovative services, contributing to the establishment of the European Mobility data space announced in February 2020.

The chapters 3 -14 of this book present the main findings of the work carried out in the European ITS Platform in the period 2015-2021. More detailed information on the achievements can be found at the website[11] of the European ITS Platform. Recordings of EU EIP webinars can be found at the EU EIP YouTube channel[12].

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[10] Digitalisation of road transport in Europe - Highlights from benefits of the ITS program co-funded by CEF – edited by SINA on behalf of the European ITS Platform - ISBN 9788897212126 - https://www.its-platform.eu/wp-content/uploads/ITS-Platform/HighlightsFiles/2021/EUEIP_DIGITALIZATION_FINAL_web_version.pdf

[11] European ITS Platform: www.its-platform.eu/achievement

[12] YouTube channel European ITS Platform: https://www.youtube.com/channel/UC1jGxvIZz8vz8BRGLNhO9tQ

3 A Reference Handbook for Harmonised Implementation of Core ITS Services

Author: Orestis Giamarelos (BASt)

3.1 Introduction

The expectations placed on the existing European transport infrastructure are increasing due to the growing mobility needs of the population on the one hand and the rising volume of freight traffic on the other. Intelligent Transport Systems (ITS) enable managing traffic flows and keeping users informed, thus making the best use of the infrastructure. Traffic and data flows are increasingly converging within Europe, making it even more important to harmonise the technical and organisational framework conditions.

A revision of the ITS Deployment Guidelines, originally developed in the Easyway and EIP+ projects, was necessary to maintain compliance with the regulations, especially due to the entry into force of the Delegated Regulations for the provision of: information services for safe and secure parking areas for trucks and commercial vehicle 885/2013[13], road safety relevant traffic information 886/2013[14], EU-wide real-time traffic information services 2015/962[15] and EU-wide multimodal travel information 2017/1926[16]. Within the framework of the European ITS Platform (EU EIP), co-financed by the European Commission, the ITS Deployment Guidelines were fundamentally revised to harmonise the technical and organisational implementation of ITS and consolidated into the Reference Handbook for ITS core service deployment in Europe (short: Reference Handbook). At the same time, many innovations have been introduced, ensuring that the content is comprehensive and up to date, as well as to underpin its credibility and relevance.

3.2 The Drafting Process

The development of the Reference Handbook lasted approximately four years. The main part of the work took place within the three Expert Groups of the Monitoring and Dissemination activity of the European ITS Platform (Traveller Information Services, Traffic Management and Freight & Logistics), which consist of experts from most EU Member States on the respective fields. The Cross Corridor Cooperation task, under the same activity, ensured a stream of valuable experiences, results and lessons learnt from real ITS deployments on the ITS Corridors, while the other EU EIP Activities, Working Groups and Task Forces contributed with their results and expertise. In addition, collaboration with the PSA DATEX II led to the development of recommended DATEX II service profiles, while based on the Collaboration Note between C-Roads and EU EIP references to relevant C-ITS use cases are introduced.

An extensive dissemination plan that started already at the early stages of development of the Reference Handbook, presenting its development to external stakeholders, other ITS projects co-financed by the EU as well as national, European and international conferences paved the

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[13] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32013R0885

[14] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32013R0886

[15] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32015R0962

[16] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32017R1926

way for its introduction and provided the development team with comments and suggestions from the ITS Community.

Finally, a series of feedback phases of the draft Handbook gave the opportunity also to its prospective users to extensively comment and contribute with their ideas and suggestions to its further expansion and improvement. The last external commentary phase of the handbook resulted into more than 1.300 comments submitted, coming from 19 organisations from 8 member states, as well as the European Commission, CEDR and ASECAP. Resolving all comments received took months of meetings and discussions within the group, documenting the decision for every comment received.

Figure 3.1: Meeting of the Expert Groups on the Reference Handbook

3.3 The Conceptual Setup

The content of the Reference Handbook is based on the ITS Deployment Guidelines, originally published in 2012 as a major outcome of the project EasyWay and then updated within the EIP and EIP+ projects in 2015. In the framework of the EU EIP project, their content received a complete overhaul, expansion and update to the current state of the art and all the Deployment Guidelines were consolidated into one Reference Handbook. This timeline is graphically presented in Figure 3.2.

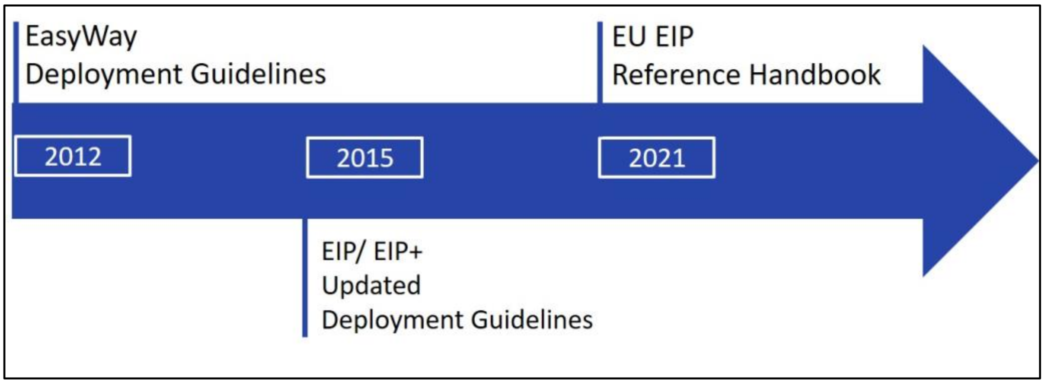

Figure 3.2: Timeline of development

The original set of 19 separate documents of the ITS Deployment Guidelines developed within EasyWay & the European ITS Platform in the previous years is now consolidated into one handbook, eliminating repetitions and redundancies and having all knowledge on ITS core service deployment in one document.

The conceptual setup is visualised in Figure 3.3. It begins with a common part which is valid for all ITS Services and is followed by three blocks: Traffic and Traveller Information Services, Traffic Management Services and Freight and Logistic Services. Within these blocks there is a separate chapter for every ITS Service, e.g. Variable Speed Limits, Ramp Metering, Intelligent and Secure Truck Parking etc. The full list of ITS services included in the Reference Handbook is presented in Table 3.1.

Following these three blocks, there is a common annex with additional information for the interested users, covering the operating environments, presenting all deployment references collected grouped by ITS core service, as well as practical checklists to assist with service deployment.

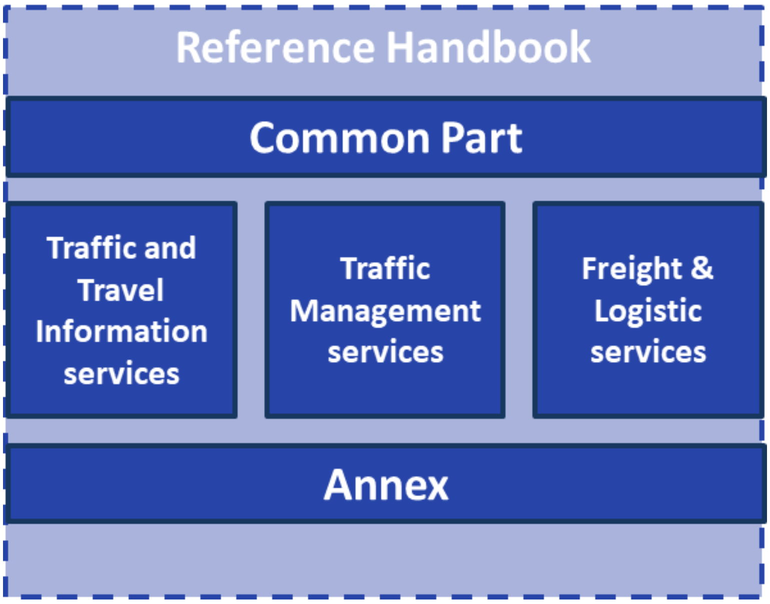

Figure 3.3: The conceptual setup of the Reference Handbook

Table 3.1: The ITS core services covered in the Reference Handbook.

Traffic and Traveller Information Services	Traffic Management Services	Freight & Logistic Services
▪ Forecast and Real Time Event Information ▪ Traffic Condition and Travel Time Information Service ▪ Speed Limit Information ▪ Weather Information Service ▪ Co-modal Traveller Information Services	▪ Dynamic lane management ▪ Variable speed limits ▪ Ramp metering ▪ Hard shoulder running ▪ Incident warning and management ▪ HGV overtaking ban ▪ Traffic Management Plans for Corridors and Networks	▪ Intelligent and Secure Truck Parking ▪ Access to Abnormal Goods Transport Regulations

The core and the primary objective of the Reference Handbook is the harmonisation of the ITS service deployment throughout Europe. For each of the European ITS Core Services, a detailed ITS service profile/description is provided, followed by a series of requirements and advice. They are formulated from a pan-European perspective in such a way that:

- functional, organisational and technical interoperability between the ITS services is achieved
- the end user can perceive and use the services offered in the same or at least a similar way (common look and feel)
- uniform implementation and evaluation benchmarks for the deployment of ITS Core services are available to the acting road operators when they intend to implement a new ITS service or improve an existing one

The requirements and advice are grouped in five categories, as shown in Table 3.2.

Table 3.2: The five categories of the requirements included in the Reference Handbook.

Requirements	**Description**
Functional	Functional architecture/structure of the service in a way that the typical main functions from data collection to information provision to the end user are depicted and identifiable.
Interface	Information structure for data exchange, as far as relevant with reference to and in conformity with the Delegated Regulations of the ITS Directive 2010/40.
Organisational	Organisational architecture/structure of the service in a way that the typical main organisational roles (of the service value chain) are identifiable and that the contractual basis of their cooperation and the principles of how they work together in operations become visible.
Common Look & Feel	“User service perception” with the intention to enable the users and partly also the operators of the service to experience a common look & feel wherever they use the service.
ICT Infrastructure	Technical standards which are useful/necessary to improve interoperability between organisations and technical systems they use to operate the service.

The requirements and advice are formed with the keywords “MUST”, “SHOULD” and “MAY”. These are to be interpreted as described in FRC 2119[17]. In order to claim compliance, a certain deployment must follow these rules:

- MUST / MUST NOT: An absolute requirement/prohibition. In case of non-fulfilment, only insurmountable reasons can be stated (e.g. legal regulations).
- SHOULD / SHOULD NOT: A strong suggestion. Non-fulfilment must be supported by very clearly described and for third parties comprehensible and traceable reasons.
- MAY: These elements are optional.

3.4 The Delegated Regulations under the ITS Directive

The purpose of the guidance provided in the Reference Handbook is to assist Member States in taking a broadly similar approach, in order to enable the achievement of wider European added value, whilst at the same time delivering the needs of individual Member States. Therefore, a major objective of the development team was to ensure compliance to the Delegated Regulations under the ITS Directive.

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[17] https://www.ietf.org/rfc/rfc2119.txt

The relevant Delegated Regulations are shown in Table 3.3. The experts of the European ITS Platform checked the data requirements resulting from these Delegated Regulations and formulated relevant requirements for all affected ITS Services accordingly. The practical gain is that users of the Reference Handbook can see easily which data elements must be provided to the National Access Points for a deployed ITS service, in order to be compliant to the Delegated Regulations.

Table 3.3. The Delegated Regulations under the ITS Directive.

(EU) 885/2013	The provision of information services for safe and secure parking places for trucks and commercial vehicles.
(EU) 886/2013	The provision, where possible, of road safety-related minimum universal traffic information free of charge to users.
(EU) 2015/962	The provision of EU-wide real-time traffic information services.
(EU) 2017/1926	The provision of EU-wide multimodal travel information services.

Note: Closing work by end 2021, the Reference Handbook does not yet incorporate the outcomes of the revision of the Delegated Regulation on RTTI, which has been recently published (February 2022).

3.5 Data Sharing Architecture

The traditional domains of road operators have now opened up to data and information exchange with actors outside their own area of responsibility (e.g. vehicle manufacturers, telecom providers, …) through various communication channels. All ITS applications process digital data, some of them process data that is input from other systems and some produce data that needs to be sent out to other systems. There are three interfaces, which are served with two types of communication (network-based communication, direct communication):

- Interface 1 realises a backbone interface that allows the service to communicate via NAPs with other third-party backbone systems.
- Interface 2 is the interface to convey information from the service into the vehicles or the user device
- Interface 3 is the interface for in-vehicle data being transmitted from the vehicle/user device to the service as a source data.

Interfaces 2 and 3 describe direct communication links (e.g. via RSUs) between the road operator and individual vehicles or other devices used inside the vehicle e.g. smartphones. More detailed information, including an architecture diagramme, can be found in the Reference Handbook.

3.6 References to C-ITS Use Cases – Collaboration with the C-Roads Platform

The emerging roll-out of C-ITS services created the need to incorporate the results achieved by the European C-ITS platform C-Roads[18]. In cooperation with the C-Roads project on the basis of the Collaboration Note signed between C-Roads and EU EIP, the experts of the two platforms checked which ITS Service may be supported by a C-ITS Service. There are several ITS Services which can be supported by a C-ITS Service and these have been mapped in the handbook. Some examples are shown in Figure 3.4.

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[18] https://www.c-roads.eu

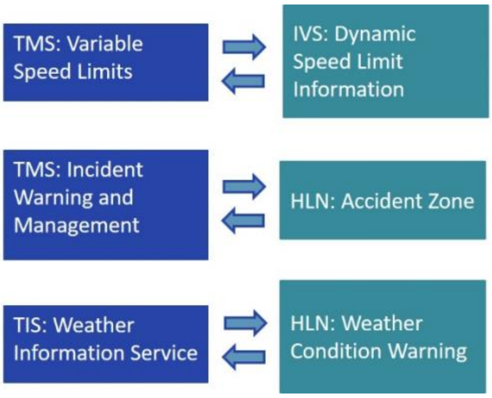


Figure 3.4: Examples of correlated ITS and C-ITS Services

In the newly introduced requirements for Interface 2, the data elements which are needed for the C-ITS use case are listed. Another requirement for Interface 3 lists C-ITS coded Probe Vehicle Data elements that need to be collected if Interface 3 is implemented.

In addition, in the newly added information provision standards the C-Roads specification for the relevant use case is referenced.

<u>Example for the ITS Service “Ramp Metering”:</u>

➢ The **Interface 2 Requirement** provides the data elements needed for the C-ITS use case:

If interface 2 is implemented, the Ramp Metering Service must provide at interface 2 Ramp Metering information coded in C-ITS messages including the following elements:

- *Signal phase*
- *Location of the ramp metering*

➢ Connected to this requirement, the **Information Provision Standard Requirement** refers to the C-Roads specification for this use case:

If interface 2 is implemented, Ramp metering information must be profiled in a Signal Phase And Timing Extended Message/MAP Extended Message, based on ETSI TS 103 301 using the C-Roads C-ITS Message Profiles for the Traffic Light Manoeuvre service.

3.7 Development of DATEX II Recommended Service Profiles

The Reference Handbook supports its users in all aspects of ITS Service deployment and not only refers to interfaces, but thanks to the collaboration with the DATEX II Program Support Action (PSA), it also provides users with a complete specification of a service-related data profile.

Experts from the DATEX II PSA joined forces with experts from the European ITS Platform, specifically the coordinators for each ITS Service in the Reference Handbook. This combined task force worked together for several months and developed Recommended Service Profiles for every ITS Service included in the handbook.

These profiles are linked in the Reference Handbook via the Interface Requirements and Information Provision Standards. The Interface Requirement 1 (covering the communication from Traffic Management Centre to the National Access Point as well as other entities) lists all data elements that need to be made accessible. In the Information Provision Standard the developed DATEX II Recommended Service Profile is referenced.

Example for the ITS Service “Variable Speed Limit”:

➢ The **Interface Requirement 1** provides the data elements that need to be accessible:

The Variable Speed Limit service must provide at Interface 1 information on the current speed limit defined in DATEX II Recommended Service Profile including the mandatory data of following classes:

— Common information

— Location Referencing information

— Road Traffic Data

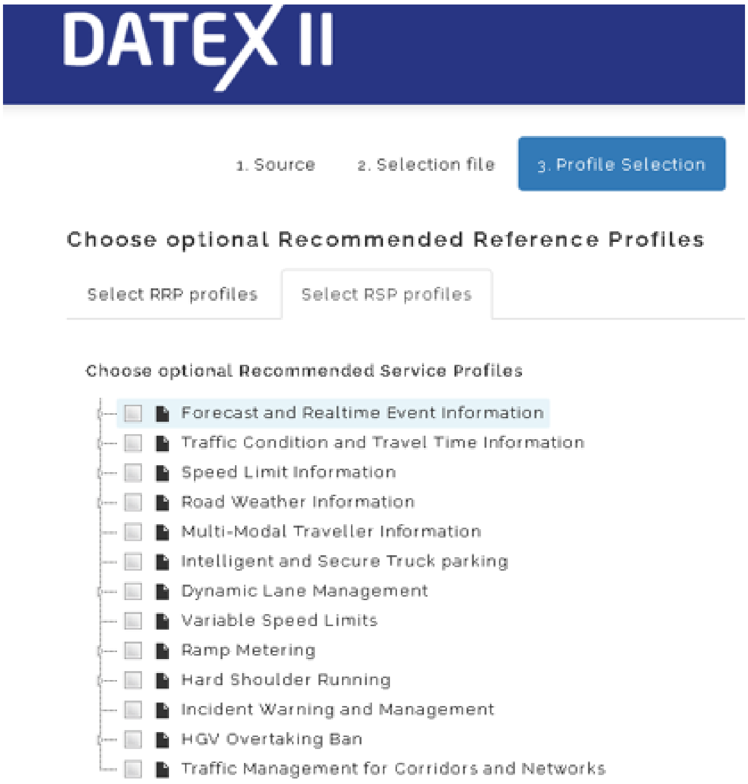
— Situation information

— VMS, includes VMS panel information

➢ Connected to this requirement, the **Information Provision Standard Requirement** refers to the DATEX II Recommended Service Profile:

If a Variable Speed Limit service is implemented at Interface 1, it must be profiled based on CEN/EN 16157-3 using the DATEX II Recommended Service Profile for Speed Limits or any international machine-readable format fully compatible and interoperable with DATEX II.

The Recommended Service Profiles are available to users via the web tool on the DATEX 2 website (https://webtool.datex2.eu/wizard). Figure 3.5 shows a screenshot of the wizard where the list of available Recommended Service Profiles is shown.



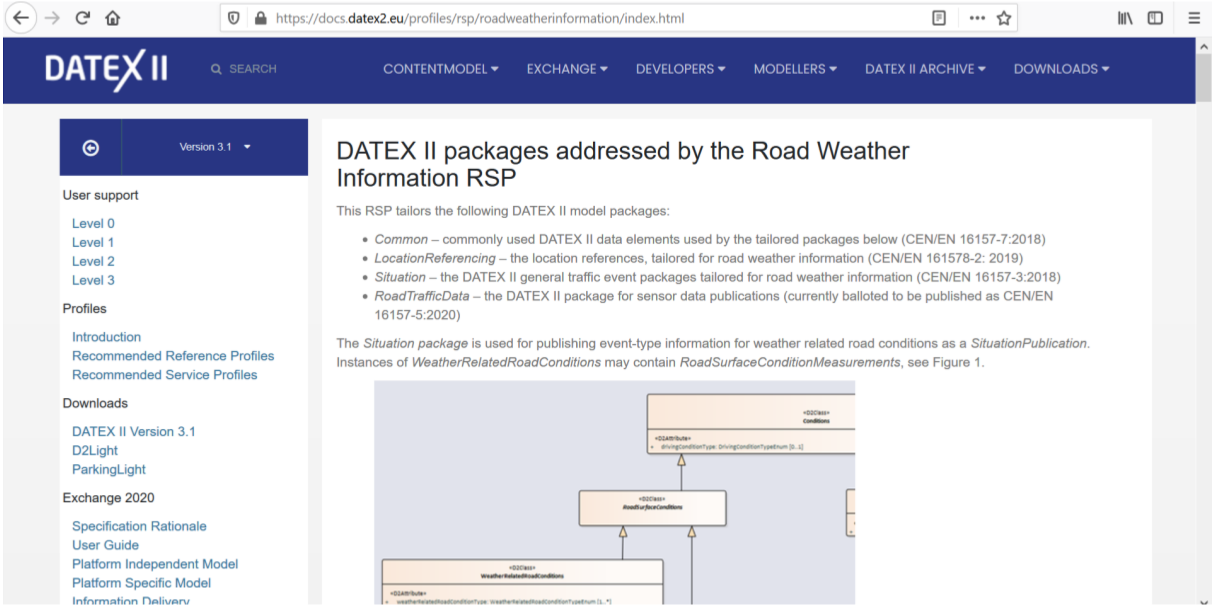
Choose optional Recommended Reference Profiles

Choose optional Recommended Service Profiles

- ☐ Forecast and Realtime Event Information
- ☐ Traffic Condition and Travel Time Information
- ☐ Speed Limit Information
- ☐ Road Weather Information
- ☐ Multi-Modal Traveller Information
- ☐ Intelligent and Secure Truck parking
- ☐ Dynamic Lane Management
- ☐ Variable Speed Limits
- ☐ Ramp Metering
- ☐ Hard Shoulder Running
- ☐ Incident Warning and Management
- ☐ HGV Overtaking Ban
- ☐ Traffic Management for Corridors and Networks

Figure 3.5: List of available Recommended Service Profiles (Screenshot DATEX II Webtool Wizard)

In addition, documentation for the profiles is provided in order to support their use. An example for the Road Weather Information service is shown in Figure 3.6. The documentation is also provided via the DATEX II website (www.datex2.eu).



DATEX II packages addressed by the Road Weather Information RSP

This RSP tailors the following DATEX II model packages:

- *Common* – commonly used DATEX II data elements used by the tailored packages below (CEN/EN 16157-7:2018)
- *LocationReferencing* – the location references, tailored for road weather information (CEN/EN 161578-2: 2019)
- *Situation* – the DATEX II general traffic event packages tailored for road weather information (CEN/EN 16157-3:2018)
- *RoadTrafficData* – the DATEX II package for sensor data publications (currently balloted to be published as CEN/EN 16157-5:2020)

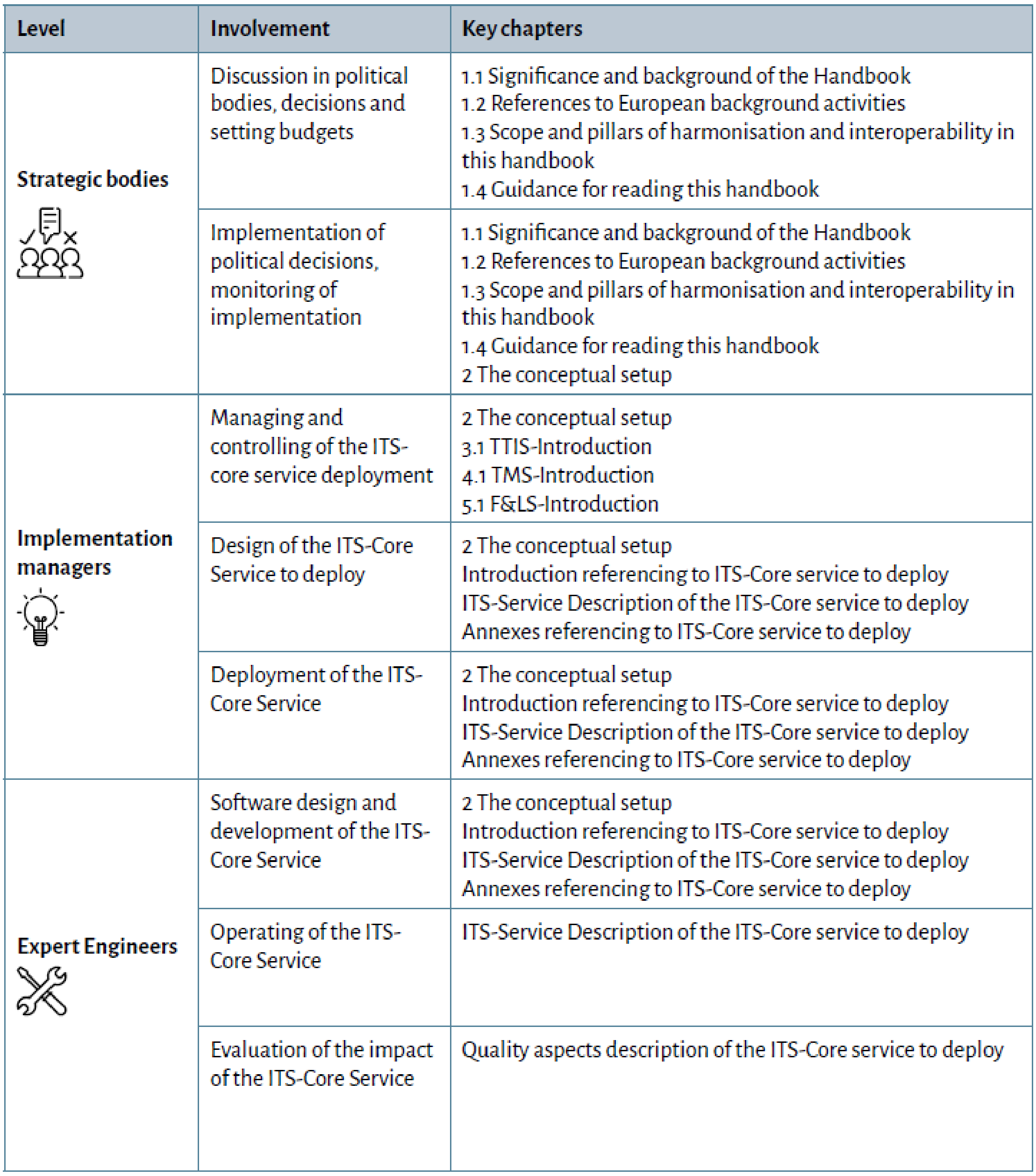
The *Situation package* is used for publishing event-type information for weather related road conditions as a *SituationPublication*. Instances of *WeatherRelatedRoadConditions* may contain *RoadSurfaceConditionMeasurements*, see Figure 1.

Figure 3.6: Documentation for the Road Weather Information DATEX II Recommended Service Profile (Screenshot from DATEX II Website – www.datex2.eu)

3.8 User Groups

An analysis of the prospective users of the Reference Handbook and their needs took place in the drafting process of the handbook. The reason is that in such an extensive document it is especially important to ensure that all interested users can easily find the information they need. This analysis led to the definition of three main user groups of the handbook (Strategic Bodies, Implementation Managers and Expert Engineers). The next step was to allocate the chapters of the handbook that are of relevance to each group. For each user group a relevant pictogram was designed and added next to the title of each relevant chapter for each group. This way each user group can easily identify relevant content in the Reference Handbook. Table 3.4 on the next page displays the different user groups, their involvement and the relevant key chapters.

Table 3.4: The identified user groups of the Reference Handbook



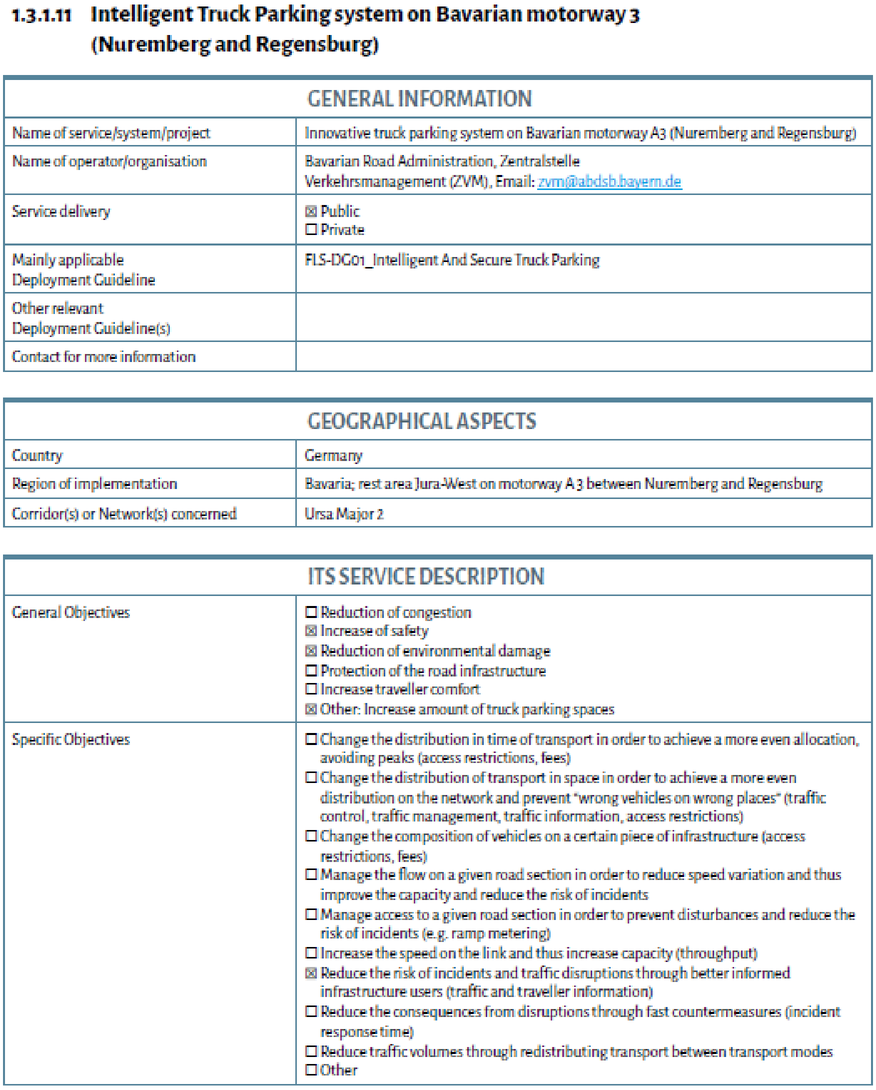
Level	Involvement	Key chapters
Strategic bodies	Discussion in political bodies, decisions and setting budgets	1.1 Significance and background of the Handbook 1.2 References to European background activities 1.3 Scope and pillars of harmonisation and interoperability in this handbook 1.4 Guidance for reading this handbook
	Implementation of political decisions, monitoring of implementation	1.1 Significance and background of the Handbook 1.2 References to European background activities 1.3 Scope and pillars of harmonisation and interoperability in this handbook 1.4 Guidance for reading this handbook 2 The conceptual setup
Implementation managers	Managing and controlling of the ITS-core service deployment	2 The conceptual setup 3.1 TTIS-Introduction 4.1 TMS-Introduction 5.1 F&LS-Introduction
	Design of the ITS-Core Service to deploy	2 The conceptual setup Introduction referencing to ITS-Core service to deploy ITS-Service Description of the ITS-Core service to deploy Annexes referencing to ITS-Core service to deploy
	Deployment of the ITS-Core Service	2 The conceptual setup Introduction referencing to ITS-Core service to deploy ITS-Service Description of the ITS-Core service to deploy Annexes referencing to ITS-Core service to deploy
Expert Engineers	Software design and development of the ITS-Core Service	2 The conceptual setup Introduction referencing to ITS-Core service to deploy ITS-Service Description of the ITS-Core service to deploy Annexes referencing to ITS-Core service to deploy
	Operating of the ITS-Core Service	ITS-Service Description of the ITS-Core service to deploy
	Evaluation of the impact of the ITS-Core Service	Quality aspects description of the ITS-Core service to deploy

3.9 Deployment References

The collection of Deployment References played an important role in the drafting of the Reference Handbook. This task, kickstarted in 2017, had the goal to collect ITS Deployment References from all over Europe, coming for the most part from deployments on the CEF ITS Corridors, as well as further national ITS deployments. The benefit of the Deployment Reference Collection task is twofold: road operators as well as interested external stakeholders can learn from each other and can join forces to avoid double work.

A template was created to collect these deployments and receive the relevant information in a standardised way. The template includes information on the ITS deployments, starting from the location of the ITS Service, the objectives, the budget, connection to different systems, benefits and lessons learnt from each deployment. An example page showing part of the template is shown in Figure 3.7.

In total circa 100 deployment references have been collected. The lessons learnt from the deployment references have been a valuable source of information for drafting the ITS service sections of the Reference Handbook. At the same time, as they can provide useful guidance by themselves as examples of deployment, they are provided in full form in an annex of the handbook, grouped and sorted by ITS Service.



1.3.1.11 Intelligent Truck Parking system on Bavarian motorway 3 (Nuremberg and Regensburg)

GENERAL INFORMATION	
Name of service/system/project	Innovative truck parking system on Bavarian motorway A3 (Nuremberg and Regensburg)
Name of operator/organisation	Bavarian Road Administration, Zentralstelle Verkehrsmanagement (ZVM), Email: zvm@abdsb.bayern.de
Service delivery	☒ Public ☐ Private
Mainly applicable Deployment Guideline	FLS-DG01_Intelligent And Secure Truck Parking
Other relevant Deployment Guideline(s)	
Contact for more information	

GEOGRAPHICAL ASPECTS	
Country	Germany
Region of implementation	Bavaria; rest area Jura-West on motorway A3 between Nuremberg and Regensburg
Corridor(s) or Network(s) concerned	Ursa Major 2

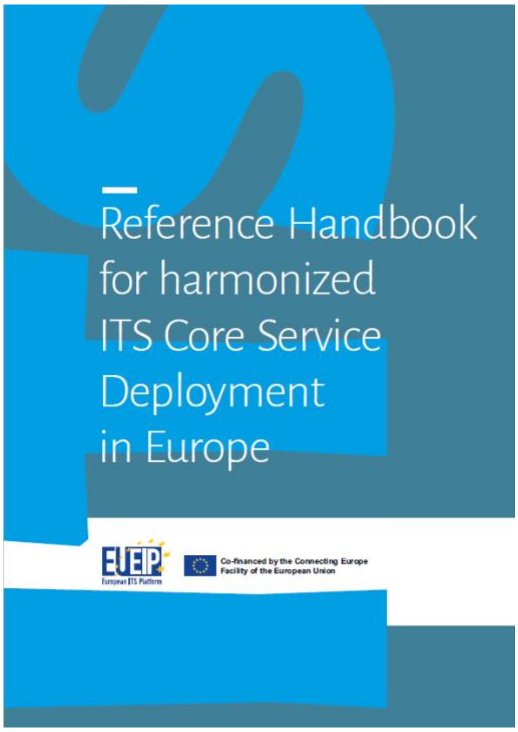
ITS SERVICE DESCRIPTION	
General Objectives	☐ Reduction of congestion ☒ Increase of safety ☒ Reduction of environmental damage ☐ Protection of the road infrastructure ☐ Increase traveller comfort ☒ Other: Increase amount of truck parking spaces
Specific Objectives	☐ Change the distribution in time of transport in order to achieve a more even allocation, avoiding peaks (access restrictions, fees) ☐ Change the distribution of transport in space in order to achieve a more even distribution on the network and prevent "wrong vehicles on wrong places" (traffic control, traffic management, traffic information, access restrictions) ☐ Change the composition of vehicles on a certain piece of infrastructure (access restrictions, fees) ☐ Manage the flow on a given road section in order to reduce speed variation and thus improve the capacity and reduce the risk of incidents ☐ Manage access to a given road section in order to prevent disturbances and reduce the risk of incidents (e.g. ramp metering) ☐ Increase the speed on the link and thus increase capacity (throughput) ☒ Reduce the risk of incidents and traffic disruptions through better informed infrastructure users (traffic and traveller information) ☐ Reduce the consequences from disruptions through fast countermeasures (incident response time) ☐ Reduce traffic volumes through redistributing transport between transport modes ☐ Other

Figure 3.7: Part of a filled template

3.10 Official Publication

Even after completing the work on the content of the handbook, great care was taken to ensure that the layout of the final document fits the purpose and the target group, facilitates the finding and reading of the rich information in it and is also aesthetically attractive. For this reason, a media agency was consulted to create a suitable layout and graphics for the Reference Handbook, leading to the creation of an accessible PDF document, as well as a printed version. The annex containing all the collected Deployment References is also provided as a separate accessible document. All documents are available for download from the website of the European ITS Platform (www.its-platform.eu/reference-handbook).

The Reference Handbook made its official debut at the ITS World Congress 2021 (11-15 October 2021) in Hamburg, Germany. During the Congress, printed copies were available and relevant videos were shown at the stands of the European Commission and the German Federal Ministry of Transport and Digital Infrastructure. A presentation of the Reference Handbook also took place as part of one of the technical sessions.



Reference Handbook
for harmonized
ITS Core Service
Deployment
in Europe

EU EIP
European ITS Platform

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

Figure 3.8: The cover of the Reference Handbook

3.11 Conclusion and Outlook

The Reference Handbook for Harmonised Core ITS Service Deployment in Europe, created by ITS experts and practitioners and refined in a commentary process by member states' experts, constitutes an essential basis for a harmonised and cross-border implementation of ITS services. Thus, it is a powerful tool in the effort to master the ever-increasing challenges the European transport infrastructure faces. It enables road operators and road authorities to equip the transport systems in a target-oriented and efficient way, providing them with guidance and support for ITS deployment on their networks. It makes a significant contribution to maintain a competitive European economy and constitutes a major component on the road to a modern and climate neutral society.

Connected mobility and autonomous driving will bring new opportunities for road operators and road authorities but also significant new challenges, which will require a joint and coordinated effort. A European activity which offers a platform for a practical exchange of experiences and lessons learnt, as well as the development of harmonisation activities for ITS will continue to play an important role in the common effort to make the transport system safer, more efficient and environmentally friendly.

4 KPIs of ITS Deployment – ITS Costs and Benefits on ITS Corridors

Author: Daniel Cullern (Capita for National Highways/Arc Atlantique)[19]

4.1 Introduction

This chapter provides an overview of the work undertaken by the EU EIP Evaluation Group to harmonise a consistent approach to the evaluation of co-funded Intelligent Transport Systems (ITS) ITS projects. It also demonstrates the significant benefits that this approach has yielded to date based on the results from the ITS Corridors which have adopted the approach.

DG-MOVE, INEA and European road authorities have been working together for several years to implement ITS systems and services in response the ITS Directive 2010/40/EU, in particular the wider deployment of Safety-Related Traffic Information (SRTI) and Real-Time Traffic Information (RTTI), better traffic management and services relating to the freight industry. The implementation of these services has primarily been through the five 'ITS Corridors', each of which corresponds to defined stretches of the trans-European Core and Comprehensive networks which, in many cases, coincide with the CEF Core Network Corridors (CNCs).

Using expertise from within the European operator and supplier communities, the EU EIP compiles supporting guidance and advice to assist road authorities and operators to evaluate the beneficial impacts of ITS implementation on road efficiency, safety and the environment in support of European policy objectives for transport.

To this end, the EU EIP Evaluation Group has developed a fully adopted suite of tools to harmonise the approach to evaluation within the ITS corridors and, on this basis, to demonstrate the significant benefits of EU co-funded Intelligent Transport Systems projects targeting mobility inefficiencies, improved safety and reduced environmental pollution on the trans-European road network.

4.2 The Achievements of the EU EIP Evaluation Group

4.2.1 The Evaluation Group and its objectives

The Evaluation Group of the European ITS Platform (Activity 5) comprises experts from the EU EIP Member States and all CEF funded ITS Corridors and, throughout the EU EIP, has benefitted from a strong active representation from its membership. The Evaluation Group has built on the work undertaken in preceding programmes in order to develop a suite of tools and support materials to enable a harmonised approach to ITS evaluation reporting which produces consistent results.

4.2.2 The EU EIP Evaluation Approach

Integral to the EU EIP evaluation approach are the common KPI Definitions. These were developed through extensive consultation with Member State experts, ITS Corridors and DG MOVE with the intent of providing a single convenient and practical reference point for

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[19] Other main contributors to this chapter include Paul Wadsworth (Capita for National Highways / Arc Atlantique), Lone Dörge (Genua Consult for Danish Road Directorate / NEXT-ITS), Merja Penttinen (VTT for Finnish Transport Agency / NEXT ITS), Bernard Fer (on behalf of ASFA for MedTIS), Paola Mainardi (SINA S.p.A. / URSA MAJOR), Luca Studer (Politecnico di Milano for SINA S.p.A / URSA MAJOR).

evaluators. It is comprised of agreed deployment and impact KPI definitions as well as suggested innovative estimation methods for calculation and draws significantly on various sources and work on the subject, including the ITS KPI definitions developed by DG MOVE and the body of work undertaken within preceding evaluation studies.

A common Evaluation Report Template (incorporating guidance) was developed. This is consistent with and structured in line with the European ITS Platform KPI definitions for the purpose of ensuring that a common approach to evaluation reporting was adopted. The KPI Definitions and Evaluation Report Template have been widely promoted and are publicly available and downloadable from the Evaluation Library (https://www.its-platform.eu/EvalLib).

The European ITS Platform ITS Toolkit (https://its-toolkit.csl-inn.co.uk) is an extensive database of key meta-data from available Corridor Evaluation Reports. The Toolkit is a “live” publicly accessible online tool for filtering ITS Evaluation results by 6 key criteria (Deployment KPI, Benefit KPI, Location, Corridor, ITS Directive Priority Area and ITS Directive Priority Action) and enables users to directly locate relevant Evaluation Reports.

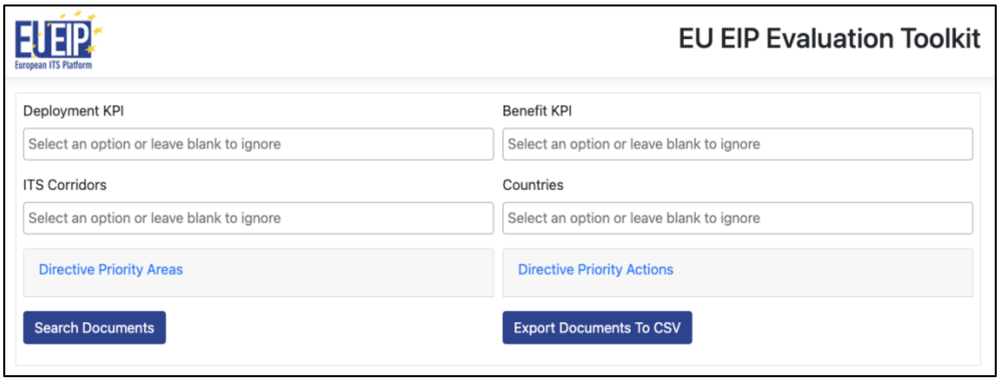

Figure 4.1: The EU EIP Evaluation Toolkit

The EU EIP Evaluation website (https://evaluation.its-platform.eu/), which promotes the results of the Activity, also incorporates an extensive Evaluation Library (https://www.its-platform.eu/EvalLib), which serves as an access point for all EU EIP Evaluation reference and guidance materials, as well being a repository for Evaluation Reports from the ITS Corridors and an archive of pre-CEF ITS Evaluation Reports and support materials.

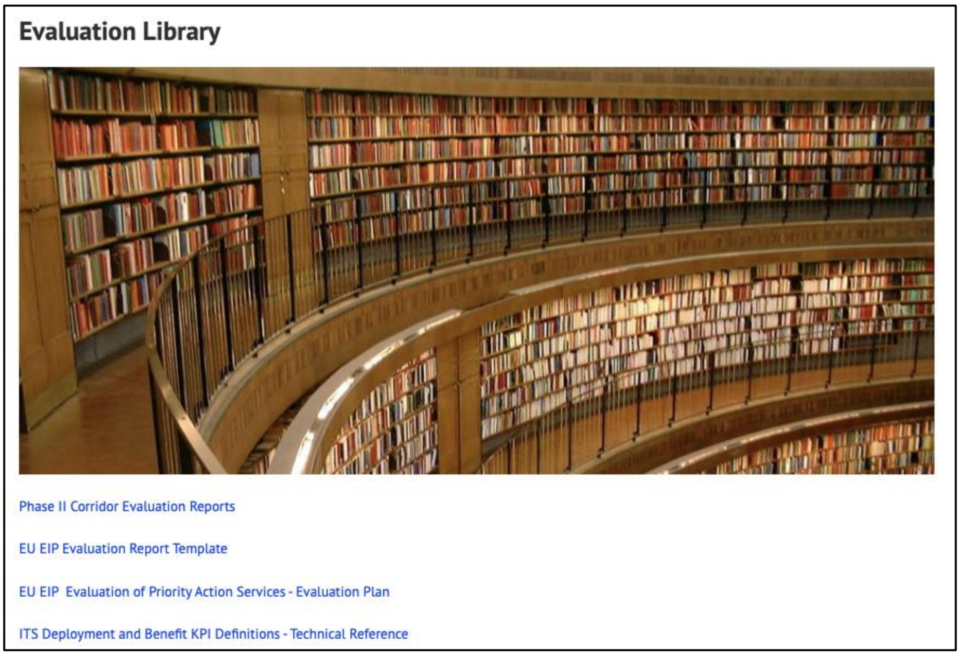

Figure 4.2: The EU EIP Evaluation Library

4.2.3 Uptake of the Evaluation Deliverables and Added Value

The EU EIP Evaluation Group has benefitted from strong, regular, direct Corridor engagement throughout the programme, and ITS Corridors have, in turn, been integral to the development of the common approach defined in the European ITS Platform support materials. Indeed, the corridors have fully adopted the harmonised European ITS Platform approach by aligning to the KPI definitions, using the report template and transferring their results into the ITS Toolkit.

As above, the EU EIP KPI definitions were developed in parallel to (and are explicitly cross-referenced with) the high-level ITS KPI definitions developed by DG MOVE for the purpose of Member State reporting. Although the European ITS Platform KPIs are more detailed, they are nonetheless consistent with the DG MOVE KPIs.

In the following sections some good examples are summarised of the type of impacts reported by ITS Corridors to date (2021).

4.3 Arc Atlantique ITS Corridor

4.3.1 Overview and Objectives of the Arc Atlantique ITS Corridor

The purpose of the Arc Atlantique ITS Corridor is to accelerate the deployment of traditional and innovative Intelligent Transport Systems (ITS) systems and services on the Core and Comprehensive networks. This is with the key objectives of:

- Increasing the efficiency of the trans-European road network
- Improving safety
- Improving environmental performance

These objectives are consistent with EU policy objectives committed to reducing the overall cost of transport to the economic benefit of the Union, reducing societal impacts through improving the safety record of the network, delivering improved air quality and contributing to the delivery of the Paris Agreement on climate change. Furthermore, through having a positive impact on congestion, particularly at bottlenecks, the ability for the Union to deliver goods and services more effectively supports transport cohesiveness, economic vitality and wellbeing.

The Arc Atlantique ITS corridor network is largely aligned with the North-Sea Mediterranean and Atlantic Core Network Corridors. Together, the corridors work towards improved multimodal transport links across the western reaches of the Union and for which the Arc Atlantique ITS corridor deploys technology and digital services on the road network.

Partner Member States comprise, Ireland, United Kingdom, the Netherlands, Belgium, France, Spain and Portugal and are supported and funded by the Connecting Europe Facility. The partners are all public highway authorities or concessionaires operating on behalf of public authorities.

4.3.2 Targeting Known Problems, Adopting a Harmonised Approach

The Arc Atlantique works in conjunction with the European ITS Platform (EU EIP) and the other ITS Corridors to build a common approach to deployment and makes use of agreed common performance indicators to measure impacts and benefits on the network.

The Arc Atlantique Corridor focus is to deploy ITS enabled traffic management and safety solutions in known problem areas, such as bottlenecks, and on routes with chronic and acute congestion which cause increased transport costs, pollution, and are often associated with an unsatisfactory safety record.

Furthermore, it extends and builds digital communications and cross-border cooperation through the implementation of harmonised systems and services such as Real Time Traffic Information and Safety Related Traffic Information whilst contributing to multimodal information via National Access Points. These are implemented in accordance with applicable European Regulations and assist Member States in meeting their obligations under the ITS Directive.

4.3.3 Achievements – a snapshot

The Arc Atlantique is being implemented over three phases and the work was completed in 2021. The following section highlights some of the Arc Atlantique Corridor achievements to date.

For the Arc Atlantique 1, 22 Real Time Traffic Information schemes were implemented on the corridor, benefitting 19.000 km of network. The work included upgrades to traffic management centres and new digital communications. For the same period, 19 projects concerning Safety Related Traffic Information were implemented, benefiting 7.600 km of the network. Furthermore, the network received new and improved services in co-modal information, truck-parking and the roll out of DATEX II.

The Arc Atlantique 2 implemented a further 36 ITS projects designed to deliver enhancements in traffic and congestion management, safety and environmental improvement, amongst others, at specific locations on the network.

The improvements delivered to users and operators during the current Arc Atlantique 3 relate to significantly enhanced levels of service through the deployment of ITS on over 16.000 km of the network, with over 60 projects aimed at improving traffic management and traffic information services.

4.3.4 Estimated Benefit over the 5 Year Programme.

Using modelling it is possible to estimate the impact of the new and improved ITS systems and services deployed on the completed Arc Atlantique 2 network over a period of 5 years. Expected savings are as follows:

- 236 slight injuries saved per year (1.180 slight injuries over 5 years)
- 28 seriously injured saved per year (140 seriously injured over 5 years)
- 11 fatalities saved per year (55 fatalities over 5 years)

Applying these different realistic hypotheses and taking into account the level of investment, the Arc Atlantique 2 programme as a whole will deliver minimum safety socio-economic savings of 36 M€ per year and a projected ROI of about 3 years.

4.4 MedTIS - Mediterranean Corridor Deploying Traveller Information Services

4.4.1 Objectives

The MedTIS main objective is to foster the implementation of ITS (Intelligent Transport Systems) for better Traffic Management Service and better Traffic information Service on the Core and Comprehensive networks of the Mediterranean Corridor. By contributing to the evolution of local traffic management modes towards coordinated and cross-border management modes, MedTIS has a key role in improving corridor efficiency in terms of road safety and capacity of the trans-European road network.

4.4.2 Achievements

By developing its actions over nearly 9.000 km with a budget of more than 50 million euros, the MedTIS project directly addresses the objectives of the ITS directive to smooth road traffic on major networks whilst improving user safety and environmental performance. MedTIS is therefore perfectly in line with the EU's objectives of decreasing societal costs by reducing the number of road victims and improving air quality. These objectives have been stressed in the new EU mobility package and its action plan.

Gathering almost thirty public and private road operators from the Members States of Italy, France and the Iberian Peninsula, MedTIS contributes to a better management of a strategic axis serving several major ports such as Venice, Genoa, Marseille, Barcelona and Valencia. As such it addresses areas where the traffic conditions are often difficult with high levels of traffic, especially during summer migration periods, heavy truck traffic, large international flows, but also, in some sectors, significant commuter traffic.

Main actions to improve control, information and traffic management are the following:

- the deployment of automatic event detection equipment
- the deployment of the first on-board information systems
- the deployment of speed control systems
- the displaying of truck parking occupancy information

Moreover, one of the key actions of MedTIS was to develop a flagship project: 'cross-border travel time project' that has significantly improved the operations efficiency and the level of service on France-Spain and France-Italy borders.

Through a close collaboration between the three cross-border operators, who developed their exchanges of traffic information and traffic data, and thanks to DATEX II, new border traffic management plans and generalized travel time services have been deployed between Spain, France and Italy.

4.4.3 Results

Overall, from the beginning of 2014 to end of 2018, MedTIS program actions have deployed 85 projects, ten of which were assessed, using ex-post or ex-ante evaluations, based on EU EIP indicators (change in accident numbers and severity, change in bottleneck congestion, change in CO_2 emissions)

These projects, of local impact, have been deployed to better respond to the specific issues encountered on the MedTIS2 network:

- improving traffic management and reducing congestion on critical spots, such as the approach of big cities, and cross-border areas
- improving safety on tunnels and their surroundings
- improving quality of traffic and event information to users, including travel times information

The deployments chosen for individual evaluations cover different road configurations (cross border sections, inter-urban sections, urban sections, mountain areas with tunnels), and different levels of equipment. So, the impact on benefit KPIs is different from one deployment to another.

Regarding impact on congestion and on environment, the benefits of those local projects range from a reduction of 2% to 10% in lost hours and CO_2 emissions volumes.

Concerning safety, the benefits of those local projects can go from a reduction of 2% to 5% in accidents numbers.

When comparing an individual deployment's costs and benefits, the results can be equally diverse, but all satisfactory: ROI is between two and nine years, but most of the projects have a ROI between two and five years.

New or enhanced traffic management services now covers more than 6.600 km of the corridor. New or enhanced traffic information services now covers 2.300 km the corridor.

This extension of proven traditional systems will bring significant benefits in the management and enhanced level of service of this ITS corridor and, through use of the most innovative telecommunication solutions, will facilitate the introduction of connected and automated vehicles.

The general improvement in the level of congestion and road safety therefore is significant and can be highlighted with concrete figures.

For this purpose, and since a full evaluation of this type of program requires at least five years, a methodology has been developed that can immediately and realistically extrapolate the full impact of the programme. Overall, the operational and practical impact of most of the projects deployed in the program of motorway operators is to shorten response times in the case of an event or accident. These projects therefore make it possible to reduce the occurrence of secondary accidents. Founded on that basis, the methodology developed for this evaluation demonstrates that this ITS deployment programme potentially reduces the number of accidents and congestion levels on the concerned motorway networks by 1,6%. This figure, well in line with those produced by other European reports delivered on the subject (e.g., OECD report: Impact of new technologies on Road Safety) leads to very significant impact results of the program.

Overall, MedTIS 2 network, over a period of five years after deployment of the programme, one can expect potential savings of:

- 8 fatalities
- 53 seriously injured and 277 slightly injured for the safety figures
- 642.000 hours lost
- 2.700.000 fuel litres
- 7.200 CO_2 tonnes for the congestion volumes

4.4.4 The socio-economic benefits

The socio-economic benefits corresponding to these savings, calculated from the figures presented in the "handbook on external costs of transport on road safety", amount to 9,42 M€ per year. For the investment program deployed in MedTIS, that leads to a ROI of roughly five years.

As these overall results come from projects that do not cover all the actions deployed in the programme, they must be considered as minimum results. In practice, the result will probably be even better.

In conclusion, these various projects and actions are fulfilling the objectives and goals for which they were targeted. They have thus contributed significantly to improving traffic safety and fluidity as well as the environmental performance and continuity of service on the MedTIS 2 networks.

4.5 NEXT-ITS

4.5.1 Overview

The NEXT-ITS 2 corridor forms the Northern part of the Scandinavian–Mediterranean Corridor. The corridor connects Northern Europe with Western and Southern European transport networks. It offers the primary road transport connections between Western/Central Europe and Norway and the St. Petersburg region of Russia.

During the last decade increased traffic load and extensive presence of HGVs has made the NEXT-ITS corridor and core network vulnerable to disturbances. The road network of the sparsely populated areas of Northern Europe offers limited possibilities for alternative routes and large parts of the network is subject to recurring hard weather conditions, particularly in wintertime.

4.5.2 Objective

The main objective of the NEXT-ITS 2 has been to improve the network performance - in terms of efficiency, reliability, safety, and environmental impact - of the Northern part of the Scandinavian- Mediterranean CEF corridor from Oslo and the Finnish-Russian border in the north via Copenhagen, Hamburg, and Bremen to Hanover in Germany. Cross-border continuity of traffic management services have been targeted through coordinated deployment of Traffic Management services and major upgrades of Traffic Management centres.

Figure 4.3: Traffic management centre in Finland (© Lone Dörge).

The measures included in NEXT-ITS 2 have been chosen in order to fill the gaps concerning coverage, accessibility, dissemination, quality and content of the core traffic management services as well as to improve the cost-efficiency in the operation of traffic management. The following deployment projects were completed during NEXT-ITS2:

- Implementation and upgrade of Traffic Management Centres
- Development and implementation of Traffic Management Plans
- Update of roadside control software to enable service integration
- Implementation and update of roadside information panels for driver information and control
- Data fusion and data quality control at Traffic Management Centres

As basic network for the assessment of the deployment KPIs of NEXT-ITS 2 measures, the comprehensive TEN-T Network has been used. The measures of NEXT-ITS 2 address mainly the Northern part of the Scandinavian-Mediterranean Corridor, but also influence the adjacent road network to the corridor and – in particular where general improvements and enhancements of traffic centres are carried out – larger parts of the main road network. Therefore NEXT-ITS 2 has estimated the impacts on the network which is influenced by the services deployed. The impacts are not limited to the NEXT-ITS Corridor but are the total estimated impacts on the affected network. The reason is that NEXT-ITS 2 contained a number of deployments in relation to central systems in traffic management centres and these system upgrades in reality affect a larger network than just the corridor itself. Thus, when including all the costs in relation to the deployments, one should also include all the benefits.

4.5.3 Cost-benefit analysis of NEXT-ITS2

When calculating the ***costs***, all the costs related to those measures which were fully deployed during NEXT-ITS 2 are included. Overall, the costs are included in CBA calculations if and only if the respective benefits are included, too. This explains the inclusion of Norwegian costs into the total costs, even if they did not receive any EC funding for their deployment; Norwegian figures are also included into the benefit calculations. For a 5-year period, the estimated implementation costs of all NEXT-ITS 2 deployment measures are circa 33 million € (including VAT), and the annual operation and maintenance costs circa of 3 million €, resulting in 15 M€ for five years. This results in total costs of 48 M€ for five years.

With respect to the ***benefits***, the NEXT-ITS 2 evaluation was focused on estimating the "average" annual total benefits. The evaluation work did not include trying to estimate the level of minimum benefits, nor an interval of impacts. Instead, the work was concentrated on performing a socio-economic assessment based on "average impact per year" and subsequent sensitivity analyses.

The five-year benefits of NEXT-ITS2 deployments are the following:

• vehicle hours driven	- 2.035.000 h
• vehicle hours spent in congestion	- 571.000 h
• fatalities/fatal accidents	- 0,51
• non-fatal injuries/injury accidents	- 10,8
• CO_2 emissions	- 45.600 tonnes

Overall, the estimated main impacts of NEXT-ITS 2 measures are seen especially in improved traffic flow, indicated with the KPIs vehicle hours driven (reduced by 400.000 vehicle hours per year), and vehicle hours spent in congestion (reduced by 114.000 vehicle hours per year). This is a result of the deployed measures, which aimed mostly at improving traffic and incident management, and supporting it with the improved traffic information.

In addition, nine thousand tons of CO_2 emissions are avoided annually due to NEXT-ITS 2 deployments. Moreover, the very conservative safety benefit estimate was an annual reduction of two severe accidents.

Even with these conservative estimates, the total value of the annual benefits in 2017 is calculated to be circa 12 million €, which can be compared to the implementation costs of circa 33 million € (including VAT) and annual operation and maintenance costs 3 M€ (or 15 M€ for 5-year period), which leads to a ROI of roughly four years.

4.5.4 Transferability of results (European Dimension)

NEXT-ITS 2 corridor and the road networks affected by NEXT-ITS 2 measures differ from the core and comprehensive networks in central Europe in the following ways:

- Much less congestion due to lack of capacity, and typically shorter duration of congestion
- Weather, especially winter weather, is a much more important source of transport problems in the Northern parts of Europe than elsewhere in Europe
- Road safety is at a somewhat higher level
- The share of incidents as a cause for congestion is higher and the share of over-demand respectively lower

For these reasons, the impacts of traffic management and information in NEXT-ITS 2 tend to be lower than they would be in central Europe on travel times, especially outside congestions whereas the impacts of weather information tend to be higher.

4.6 URSA MAJOR

4.6.1 General Information

URSA MAJOR 2 targeted the deployment of ITS services to improve freight traffic on the TEN-T road network mainly along the Rhine-Alpine and the Scandinavian Mediterranean core network corridor, linking North-Sea ports, the Rhine and Ruhr area, metropolitan areas in southern Germany and in Italy. Parts of the Rhine-Danube core network corridor are also addressed due to important freight traffic routes linking these corridors in the middle of Europe.

International freight transport between EU Member States is one of the three main pillars for a Single Europe Economic Area. Improving services for international freight traffic along the mentioned corridors is the main European Added Value of URSA MAJOR 2.

Countries involved in the project are Germany, Italy and The Netherlands. Switzerland is an active partner without EU co-funding; Austria is included in its role of transit country, based on operational agreements for cross-border Traffic Management Plans.

4.6.2 Evaluation, including GIS data tool support

The main objective of the Evaluation activity is the assessment of the overall impact of URSA MAJOR Project on traffic efficiency, safety and environment, based on the results emerging from ex-post evaluation studies carried out by URSA MAJOR partners. This means that the evaluation studies are based on measured real impacts on mobility. Moreover, the comprehensive usage of Floating Car Data complements the project-wise evaluation and the URSA MAJOR study is supported by a GIS data tool.

4.6.3 Most significant results emerging from the evaluated projects

Below are the most significant results that emerged from the evaluation studies of the individual projects implemented in URSA MAJOR 2 (18 studies), divided by impact area.

- Impact on Traffic Efficiency. With regard to evaluated URSA MAJOR projects, the more remarkable impacts are the increase of traffic flow, intended as throughput, with Dynamic Line Management (DLM, +17%/+23%), the reduction of travel time with Dynamic Rerouting (DR) and DLM (770.000 hours per year and 8%/50%), a good percentage of rerouted users with DR (10%/43%), the reduction of vehicle hours lost thanks to Traffic Monitoring and Management (TMM, 48%/86%) and a good result in congestion cost savings with DR and TMM.
- Impact on Safety. The analysis on safety reported in evaluated UM projects shows few results related to this area, where the most relevant indicator is the change in ratio between the number of accident and the change in traffic flow, which results as -7% in a TMM implementation. Moreover, a safety campaign on VMS obtained 91% user satisfaction.
- Impact on Environment. The ITS service that presents more results within evaluated URSA MAJOR projects is the DLM, with a reduction in fuel consumption of 28%-55% and a change in fine particle emissions equal to -75%. In a DR application, a reduction of 3.650 tons of CO_2 per year was calculated.
- Other results presented in the analysed projects are different for each type of ITS; this makes it complex to compare data and to provide a final judgment on overall results. There is one result that must be mentioned, and is the improvement of the event detection time, which is reduced by 93%/97% in one URSA MAJOR implementation.

4.6.4 Overall impact of the project through EC Key Performance Indicators

The overall impact of UM is based on a combination of the results of UM evaluated ITS implementations and impact data available in literature (and similar to ITS realized in UM), in order to have a more solid statistical basis.

The results are expressed through the Key Performance Indicators defined by DG MOVE, using only those applicable and pertinent to UM implementations. The first step is the calculation of KPIs for each type of ITS service, using combined data from the UM evaluation studies and from literature.

After that, the impact results are extended to the whole UM corridor using a weighted average of the indicators over the number of implemented projects for each ITS service type.

The following table represents the assessed average impact along routes where the ITS systems included in the UM Project have been implemented.

Table 4.1: Benefit KPI along URSA MAJOR routes where ITS has been implemented

Impact area	**Benefit KPI along routes where UM - ITS has been implemented**	**Value**
Traffic efficiency	Change in journey time	-13%
	Change in traffic flow	+9%
Safety	Change in number of accidents	-34%
Environment	Change in annual CO_2 emissions	-22%

4.6.5 Five year estimated minimum benefit

The estimation model applied only to the Italian and German Projects allows to estimate the following annual savings:

- less 71 accidents with victims
- less 79 slightly injured people
- less 22 seriously injured people
- less 2 fatalities

By transforming these benefits into economic value, a gain of 11.5 M€ can be estimated. For the estimation of the ROI the following basic calculation can be applied: Project Investment (€) / Annual savings (€) = Number of Years. ROI = 45,878 M€ / 11.5 = 4 years

4.7 Blending results of corridors in a pan-European perspective

Based on available results from four of the five ITS corridors, pan-corridor estimated global minimum 5-year safety benefits and return on investment (ROI) have been calculated**.**

In terms of minimum safety and socio-economical savings as a result of combined programme investments over a 5-year period, it can be concluded that:

- A minimum of 75 lives will be saved
- A minimum of 2,166 injuries will be prevented

In conclusion, as a result of these safety benefits alone, it is apparent that the combined ITS Corridor investments also result in a high financial benefit. Based on the combined investment of 232 million € across the four ITS Corridors, the following minimum savings based on safety impacts alone can be established:

- A minimum annual safety benefit saving of 55 million €
- A minimum overall Return on Investment (ROI) of about four years on average
- A benefit-cost ratio of around three and higher (based on an average lifetime of ten years for the related infrastructure components).

5 East-West Corridor Feasibility Study and First Pilot Implementation

Authors: Ronald Jorna (Mobycon), Orestis Giamarelos (BASt)[20]

5.1 Introduction: The East-West Corridor

When starting the European ITS Platform (EU EIP) in 2015, it was deemed necessary to start a feasibility study on the East-West Corridor, since the various CEF[21] ITS Corridor Projects (Arc Atlantique, Crocodile, MedTIS, NEXT-ITS and URSA MAJOR) were not covering this important east-west axis. It would also be a way to integrate the Baltic States and Poland into the European ITS community. So, the East-West Corridor (EWC) was born as part of EU EIP, running from Ireland, via the UK, Benelux, Germany and Poland to the Baltic States and Finland. It is not a formal Core Network Corridor (CNC) but links the CNC North Sea – Mediterranean (purple) and the CNC North Sea – Baltic (red), as shown in figure 5.1 below.

This corridor has two specific characteristics of traffic:

1. it is an important road freight connection
2. it is a corridor with a maritime character, crossing or passing the Baltic Sea, the North Sea and the Irish Sea.

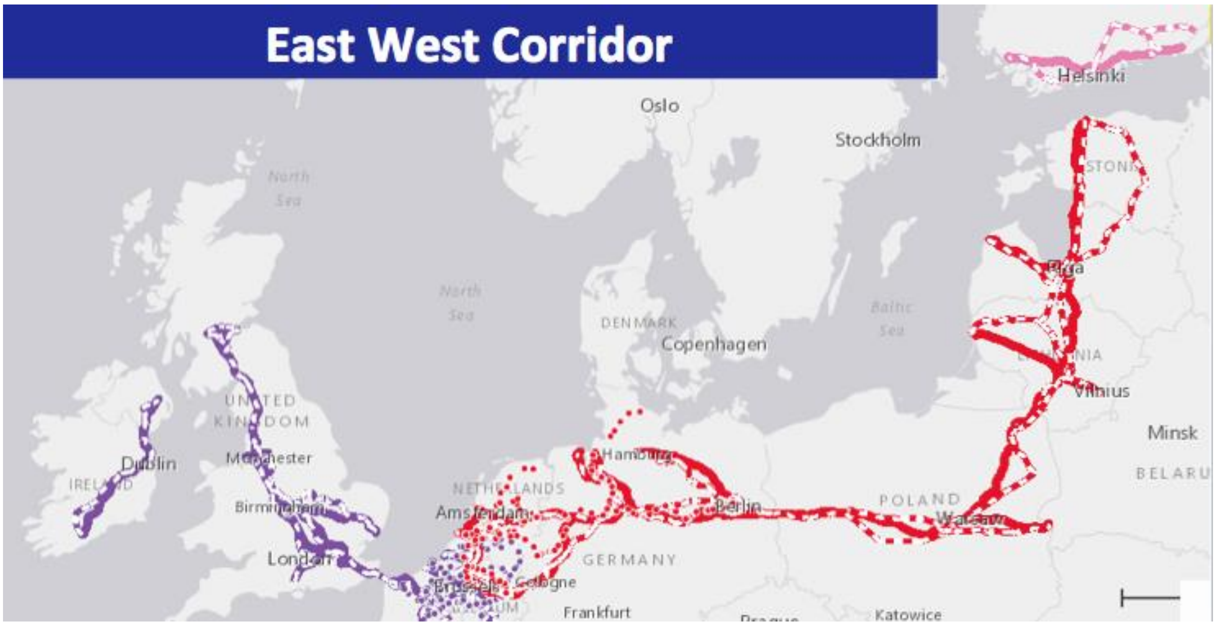

Figure 5.1: The East-West Corridor links the CEF corridors North Sea – Mediterranean (purple) and North Sea – Baltic (red)

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[20] This chapter is based on outputs produced in the East West Corridor activity of EU EIP, to which the following organisations have contributed: Rijkswaterstaat (lead), Landesbetrieb Mobilität Rheinland Phalz, Ministerium für Bauen, Wohnen, Stadtentwicklung und Verkehr des Landes Nordrhein-Westfalen, Transport Infrastructure Ireland, General Directorate for National Roads and Motorways (GDDKiA), Highways England, Swedish Transport Administration, Finnish Transport Agency, Estonian Road Administration, Port of Zeebrugge, EWTCA, BASt

[21] CEF: Connecting Europe Facility, see https://ec.europa.eu/inea/en/connecting-europe-facility

The objectives of the East-West Corridor activity in EU EIP were twofold:

1. To carry out a feasibility study for potential ITS systems and service deployments along the East-West Corridor and to identify which ones could be prioritized, adapted, enhanced and/or introduced as seamless services along the included parts of the corridor. Within the feasibility study three separate tasks were defined:
    - Creation of an ITS community on the East-West Corridor and an inventory of planned ITS investments for European seamless services
    - Feasibility study of selected planned ITS investments for European seamless services
    - Recommendations for further roll-out and/or implementations of seamless ITS services on the East-West Corridor
2. A first pilot implementation of a multi-modal route planner for freight, as an example of a seamless, harmonised innovative ITS service along the East-West Corridor.

Although the activity of the East-West Corridor initially ran from July 2015 to June 2017, exploitation of its results and further development and cooperation among its partners continued until the end of the EU EIP project in December 2021.

5.2 East-West Corridor Feasibility Study

ITS can be a valuable tool to improve conditions on an important freight transport corridor like EWC. This has been confirmed in this feasibility study. With EWC having seen a significant increase in freight transport in the last two decades, ITS can be an efficient tool to provide the required enhanced traffic performance. Achieving this on full corridor scale requires a supra national layer of coordinated operation and service orchestration in order to achieve coordinated deployment of ITS to fill gaps at local and regional level. Collaboration of operators along the corridor is essential to work towards seamless services and harmonised systems and functionality, based on shared best practice and common guidelines.

The following points highlight the main ITS topics that will benefit from a collaboration on the EWC:

- ITS deployment on the EWC would benefit from harmonisation of services that address the specific characteristics of the EWC, in particular with respect to long distance freight traffic. Intermodality plays an important role here due to the high importance of ferry links (plus the channel tunnel rail link) for road transport in the EWC.
- Although the scope of the study is limited to ITS deployment on roads, intermodal aspects (in particular with regard to ports or intermodal hubs, e.g. for rail) can be incorporated into an EWC concept by extending the core concept of traffic management plans to cooperation with ports/hubs. Ports/hubs typically operate their own road network and actually also deploy ITS services (e.g. truck parking with static and dynamic information), which are currently often not well connected with the surrounding motorway network, e.g. freight traffic leaving or arriving at the port/hub may experience a service break with potentially severe impact. Although ports/hubs are often indeed road operators themselves, we have not found evidence for traffic management plans addressing the cooperation of the port/hub (as road operator) and the operator of the surrounding network. It should be noted that regarding ports such cooperation includes, but is not limited to, ferry links. The same TMPs would also address the specific traffic patterns e.g. when large container vessels arrive at a port (and many containers are cleared via road in a short time).
- Traditional ITS service deployment for traffic management services on the EWC road network itself should also be considered. The projects themselves include the full range of traffic management services, mainly mitigating peak load impact on traffic and preventing/mitigating congestion and time loss.

- Since freight safety is a major issue, all projects addressing local hazard warnings also fit very well into the EWC context, independent from whether they apply established technology (e.g. TPEG[22]), innovative technology (e.g. C-ITS[23]) or both.
- ITS services captured under the Freight Support category address several truck parking services. Truck parking is a major issue. The concrete volume/share of Heavy Goods Vehicles (HGV) traffic should be considered (or special analysis regarding the availability of parking spaces need to be undertaken). Deployment of static truck parking information is mandatory according to Commission Delegated Regulation (EU) No 885/2013 for the whole trans-European road network in areas designated by the Member States where traffic and security conditions require the deployment of information services on the safe and secure parking places. For road sections with a high load of HGV traffic, the deployment of dynamic truck parking services should also be considered, any deployment plans in that direction would certainly suit well to be incorporated into the EWC initiative. Should the expectation be that even dynamic truck parking services are not sufficient to match expected demand, projects envisaged to extend capacity using ITS technology for optimising truck parking schemes also qualify well and should of course also be incorporated.

Geographic Information System (GIS) for ITS projects on East-West Corridor

During the feasibility study the Project Inventory GIS tool of the East-West Corridor was developed, a web application designed to visualize the various types of ITS projects implemented on the EWC network. It can be used without particular expertise by all interested parties that want to know more about the type of ITS projects implemented on this corridor. It allows the users to search for specific ITS implementations on the EWC.

Although the GIS tool provides an overview of approximately 250 ITS projects on the East-West Corridor it does not claim to be complete. The ITS projects included are provided by partners of the EU EIP project. Projects can be financed either nationally or with European co-funding (e.g. CEF).

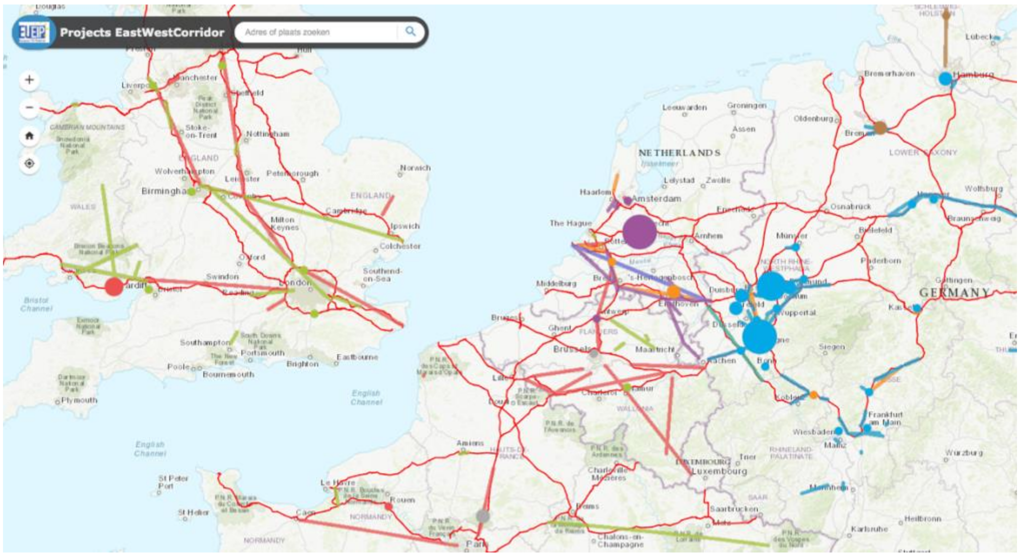

Figure 5.2: Screenshot East-West Corridor GIS tool

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[22] TPEG: Transport Protocol Experts Group

[23] C-ITS: Connected ITS

5.3 East-West Corridor Road Map

The ITS road map for an operational East – West Corridor across northern Europe is aimed at road operators who manage, maintain and invest in highways infrastructure and ITS services. It is also designed to inform DG MOVE and CINEA on a possible timeline to focus strategic investment through facilitating cross border cooperation at an institutional and operational level. In the present context, this would be via the CEF or other funding instruments. The road map presented in figure 5.3 below is a graphical high-level overview in the form of an illustrative timeline towards meeting a vision for harmonised, seamless ITS services along the East – West Corridor.

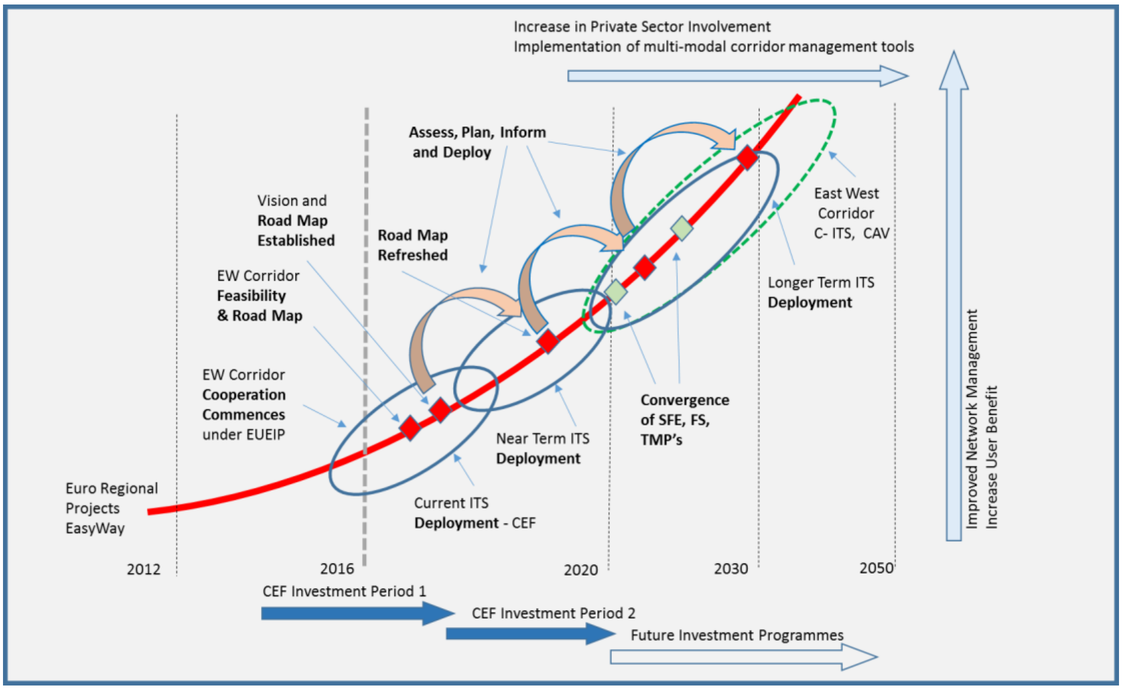

Figure 5.3: High-level overview of the East-West Corridor roadmap

The road map features some key themes:

- *Improved Network Management and User Benefit*
  Given the body of proven knowledge concerning the expected benefits arising from the provision of ITS services in its widest sense, we expect that a key feature of the road map will be improvements in the road operator's ability to manage the road network more effectively. This will in turn deliver wider benefits to traffic managers and road users of increased efficiency and better reliability.
- *Increased involvement of the private sector*
  The current trajectory of involvement of the private sector in traffic information and traffic management systems is set to increase. This is fuelled by the increasing availability of data, made available through National Access Points or via other public and private sector entities, from which new business opportunities emerge as well as new ways to deliver traffic management services.
- *Sustained investment*
  A feature of the road map is the need to continue with targeted investment along the corridor network. Up until 2012 investment in ITS was supported through the EasyWay programme but in the context of regions rather than corridors. Since 2012, investment via the CEF has occurred on the Core Network in the form of ITS corridors such as the Arc Atlantique, URSA MAJOR and NEXT-ITS. These ITS corridors have followed a largely north - south trajectory. These projects are already concluding their third phase of investment at the end of 2021 and 2022. Similarly, with the EWC, ongoing investment

will enable a strategic approach to be taken such that the targeted vision is achieved. Indeed, it is possible to see that investment in elements of the EWC has already begun during the 2013-2020 CEF investment period at strategic points along the EWC route, but in the context of the Arc Atlantique and URSA MAJOR ITS corridors. Clearly the EWC network has benefited from this work albeit 'on behalf of' existing ITS corridors. However, they have not been implemented in the context of an East-West strategy.

- *Sustained cooperation between stakeholders and convergence of existing Road Maps*
  The launch of the multimodal CEF core network corridors and in particular the success of the ITS Deployment Corridors have benefited from increasing cooperation between key actors responsible for the road network within each Member State. The EasyWay programme and more latterly the previous and current phases of the European ITS Platform have horizontal activities specifically targeted at best practice collection and dissemination, knowledge exchange, cross corridor cooperation and evaluation of the benefits arising from the ITS corridors. The European ITS Platform includes key actors from each of the road authorities who understand the issues and challenges of delivering efficient ITS services to users. Cooperation between key stakeholders under the European ITS Platform has led to the identification of the need for an East-West Corridor. Accordingly, cooperation has already commenced leading to the proposed road map described here. An outcome of this cross-corridor cooperation process will be the convergence of other ITS road maps that deal with common ITS themes. These would include for instance, the ITS Road Map and the C-Roads roadmap for C-ITS Services.
- *Accelerating Deployment of ITS Services*
  As described above, deployment of ITS services has already commenced on the East-West Corridor albeit under the umbrella of the Arc Atlantique, URSA MAJOR and Next-ITS Corridor projects. The road map indicates the need to plan and deploy in the short and medium term in the context of an East-West strategy. Work undertaken in the Feasibility Study stage of this Activity documents where there are plans to implement ITS Services on the East-West Corridor under the umbrella of existing ITS corridors to 2016. The cooperation between the partners in this Activity has allowed an indicative work plan to be created for the near- to mid-term from 2017 - 2019.
- *Creation of cross border Traffic Management Plans*
  Traffic Management Plans (TMPs) that extend across and beyond regional and national borders are the gold standard in long distance corridor management and improvement of ITS services to road users. Creation of TMPs to address common problems of efficiency, reliability of journeys and safety at specific locations on the corridor network can be promoted and implemented as stakeholders in the East-West Corridor implement the road map and work towards achieving the vision. TMPs involving other modes such as ferries and rail will become more important as will incorporation of ports and transport hubs into local and trans-national Traffic Management Plans.
- *C-ITS Services*
  Piloting of C-ITS services commenced in Western sections of the East-West Corridor in 2017. Planning for deployment of full Day 1 and 1.5 services[24] is taking place and it is expected that these new services will be deployed on a wider scale. C-ITS services are an important emerging tool for management of traffic and safety with associated environmental mitigation. Wide coverage of C-ITS services can be expected, including more advanced V2V and V2I services. Once mainstream, they will be able to allow for

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[24] The distinction between Day 1 and Day 1.5 services is based on their technological maturity. European Commission (2016) Communication 'A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility' https://goo.gl/MeLqpo

new concepts of traffic management and the use of infrastructure, further enhancing the performance of the corridor in a cost-effective way.

The need to revisit and review deployment plans on a cyclical basis is important to test progress against the road map, adjust the vision if necessary and adapt plans for future deployment of ITS Services. Evaluation of the impact of the deployed harmonised services is important to be able to understand whether benefits are achieved and whether the project remains consistent with policy objectives and technical development. Furthermore, so that the vision and road map remain responsive and relevant to potential changing characteristics of the corridor and new technologies or services are incorporated when they can deliver real benefit to the road user. An example of the latter would be planning for the introduction of C-ITS services when these are mature.

5.4 Timeline to deployment

In the previous section the road map was presented graphically as a high-level overview. In the following table the ITS services and key themes of the road map are brought together in one overview, including indicative timing of the deployment.

A difference can be seen between the near-term and longer-term actions. Most of the near-term deployments can be done at MS level, whereas for the longer-term deployment more effort should be put in coordination, e.g. information exchange between road operators, harmonisation between countries, cooperation with other stakeholders etc.

Furthermore, it can be noticed that the near-term deployments are often directed towards filling gaps, thus creating an East-West Corridor where at least the most critical spots (from a safety and/or traffic flow perspective) are covered by ITS services. The longer-term deployments are targeting higher level objectives, such as harmonised service levels, full C-ITS services, long distance and multimodal TMPs etc.

Last but not least, the difference in deployment level between countries in the East and in the West should be mentioned, leading to more short-term deployments aimed at filing gaps in the East and e.g. early C-ITS deployment in the West.

Table 5.1: Indicative timeline of the East-West Corridor roadmap

(C-)ITS services	Near-term (until 2020)	Longer-Term (2020 onwards)	Comment
Road Works & Hazard Warning	• Critical spots • Fill gaps • Early C-ITS implementation.	• Harmonised service level • Data available via NAP • C-ITS services	
TMPs	• TMPs at critical spots on the network* • Cross border TMP	• Long distance TMP • Multimodal TMP's	*likely to be in the East as well as at busy points in the West
Intermodal Freight hubs	• Timed parking at a distance • Information on available spaces • Timeslots at terminals • Information available via NAP • Intermodal information (ferry/rail)	• Multimodal TMPs	

Safety and Flow Enhancement	• Implementation of HSR, DLM, SLI+VSL, etc. (resolving bottlenecks filling gaps) • Data available via NAP	• Data available via NAP with enhanced services • Higher levels of services and data quality. • C-ITS services	Officially all MS should have established NAPs already ultimately in 2019. However, this objective has not yet been achieved in all MS.
Truck Parking	• Static truck parking data available via NAP, including non-TERN sections (e.g. hubs and urban)	• Dynamic Truck Parking data available via NAP • Intelligent Truck Parking	Officially all MS should have established a NAP for truck parking already in 2015. However, this objective has not yet been achieved in all MS.
C-ITS	• Day 1/1.5 early implementations	• C-ITS full roll out	

Abbreviations: C-ITS=Cooperative ITS, HSR=Hard Shoulder Running, DLM=Dynamic Lane Management, SLI+VSL=Speed Limit Information + Variable Speed Limits, MS=Member State, NAP=National Access Point, RTTI= Real-time Traffic Information, SRTI= Safety Related Traffic Information, TERN=Trans-European Road Network, TMP=Traffic Management Plan.

5.5 Intermodal route planner East-West Corridor

In March 2017 the East-West Corridor intermodal route planner for European container transport (available at https://www.its-platform.eu/achievement/east-west-corridor/) was launched by EU EIP. It was the first real intermodal ITS within the European ITS Platform, and as such serves as an example for other (corridor) projects in this field. It demonstrates how ITS can play a role for the better use of corridors, helping to realize European policies. The aim of the dedicated intermodal route planner on the East-West Corridor was to increase the visibility of the intermodal transport services on the corridor. Logistics companies can save on costs and reduce their environmental impact by using intermodal transport along the corridor. As mentioned earlier, the East-West Corridor is characterized by 3 maritime crossings, i.e. the Baltic Sea, the North Sea and the Irish Sea, and therefore intermodal transport seems to be an appropriate alternative for road-only transport. In addition, the intermodal route planner will function as a catalyst for cooperation on the East-West Corridor, since it will show that cooperation will lead to advantages that one cannot achieve on its own.

The Intermodal Planner for the East-West Corridor shows all possible intermodal connections in Europe with an origin and/or destination on the corridor. Through its online search engine (based on the Intermodal Links Planner) it allows users to find the best and fastest container transport services between more than 1.700 terminals in 56 countries. It determines the optimal route out of more than 20.000 direct connections offered by nearly 200 intermodal transport operators (rail, barge, and short sea). The easy-to-use interface provides quick access to all intermodal options between origin A and destination B, as well as the contact details of the intermodal operators and terminals. See figure 5.4 below for a screenshot.

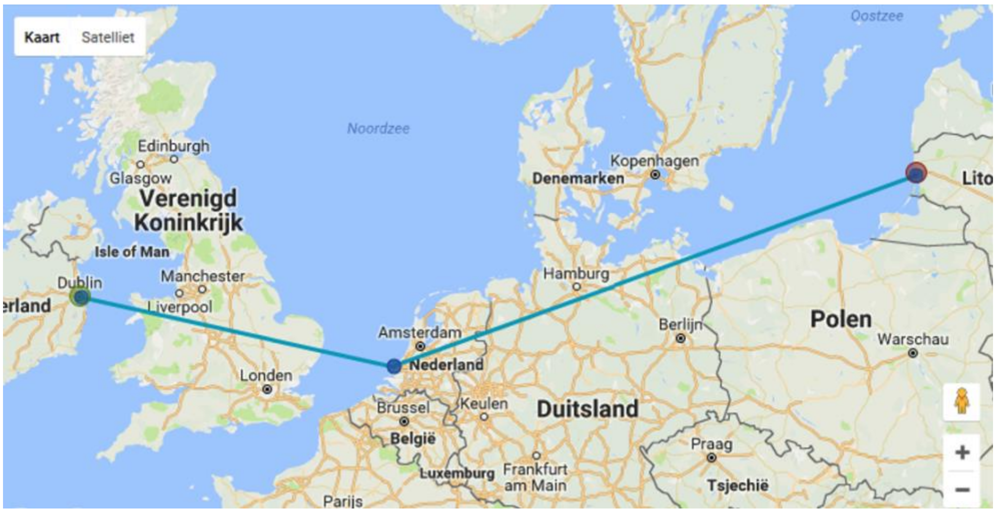

Figure 5.4: Screenshot East-West Corridor intermodal route planner

The EWC activity has contributed to the East-West Corridor intermodal route planner by adding new intermodal operators and terminals. Over a period of one year (June 2016 – June 2017) the schedules of 27 intermodal operators were added (mostly barge operators), a 21% increase on the initial number. In addition, 147 intermodal terminals have been added, an increase of 16.5%. Out of these 147 additional intermodal terminals, 67 are located on the East-West Corridor.

5.6 (Potential) developments of the Intermodal Route Planner

In the discussions on the Route Planner several issues were brought up that could improve the functionality of the planner:

- A CO_2 Calculator. Due to the increasing demand from manufacturers and consignees that every process of manufacturing and the cargo supply chain is measured in terms of harmful gas emissions, it is important that the Planner provides information on the selected door-to-door routes. This figure could be a major factor in the selection of a particular routing and set of carriers.
- A sidebar, that gives an update on the recent changes that have been made to the Shipping, Rail and Barge Operators, Terminals and service routes. This feature would facilitate checking the status of their offerings with the planner manager. It is equally important to reassure cargo owners and transporters that the Planner is, indeed, fully up to date.
- Automatic feedback from the user. This will enable the managers of the Planner to be made aware of services and connections not included in the Planner, thus, assisting its constant further development.
- Adding Ro-Ro services. So far, the focus has been on Lo-Lo shipping services. An increasing number of ferry services now carry unaccompanied trailers and ISO containers. As ferry services often run at a higher service frequency and at a higher sailing speed than Lo-Lo services, the planner would show a significantly better result for some traffics than it does at present.
- Reliability Index. This development has been suggested by a number of respondents. It is a reaction to the perceived lower reliability of Intermodal services as compared to the driver accompanied trailer option.

- Real time information. Given the fact that a number of services in an intermodal chain could run at different frequencies the through time to destination could vary considerably depending on day and time at which the movement starts.
- Expand connections to Eastern Europe and Asia. With an increasing number of freight trains running to and from China and other Asian countries, these services are becoming a significant factor in the intermodal transport mix.
- Select the mode of transport beforehand. The intermodal route planner provides the user with intermodal alternatives by rail, barge or short sea/feeder or a combination of these modes. Users might prefer selecting intermodal alternatives by mode beforehand.

Due to technological progress the Intermodal Links planner, which forms the basis for the EWC intermodal route planner, in 2020 migrated to a new technological platform (Power BI), which offers better graphical and analysis options. Since then, users of the EWC planner are redirected to the new Intermodal Links planner. Some of the developments mentioned above are already included in this updated version. The new Intermodal Links planner is accessible via https://www.its-platform.eu/achievement/east-west-corridor/.

5.7 Paris Climate Change Agreement and Brexit

The EU EIP project was launched in the aftermath of the Paris Climate Change agreement and the significant movement towards minimising CO_2 and other hazardous emissions, which would tend to push shippers and their carriers towards the use of low-emission routings. As the discussions with these groups and Government Agencies have gone on through the lifetime of the project, the level of awareness of the importance of these issues has significantly increased. As the use of Intermodal Freight Transport enables the shipper to meet his requirements more adequately in this area, the increased interest in the Intermodal Route Planner is no surprise.

The return of sturdy economic growth within the EU has also put increasing pressure on road transport operations. Within the ferry sector there is a strong swing towards the shipment of unaccompanied trailers and the use of longer ferry routes leading towards greater usage of piggyback rail to inland terminals. Typical of such shipping routes are those out of Zeebrugge to Scandinavian, British, Iberian and Irish Ports.

The decision by the United Kingdom to leave the EU has the potential to undermine the certainty for transport companies to use the United Kingdom land bridge for traffic to and from Ireland. There is evidence in member company research by the Irish Exporters Association that Brexit has already forced companies shipping to and from continental Europe to look at shipping routes avoiding the United Kingdom that are reliable, if somewhat slower than the current land bridge option.

These “disrupters” are all pushing freight transporters towards intermodal transport and increasing the need for a neutral route planner.

6 Monitoring and Harmonisation of National Access Points in Europe

Authors: Louis Hendriks (Rijkswaterstaat), Ronald Jorna (Mobycon)[25]

6.1 Introduction

Since 2016 the European ITS Platform has published annual reports about the status of the National Access Points (NAP) across Europe. The NAP 2020 Annual Report was the last one, which also concluded the work of the Working Group NAP. The Working Group NAP was aimed at monitoring, harmonisation and data exchange with respect to National Access Points across Europe, covering the following topics:

- the provision of information services for safe and secure parking places for trucks and commercial vehicles ((EU) 2013/885)
- the provision, where possible, of road safety-related minimum universal traffic information free of charge to users ((EU) 2013/886)
- the provision of EU-wide real-time traffic information services ((EU) 2015/962)
- the provision of EU-wide multimodal travel information services ((EU) 2017/1926)

These four topics are directly related to the European Commission's Delegated Regulations[26] for respectively priority actions 'e', 'c', 'b' and 'a'.

These annual reports describe the deployment status of NAPs in Europe as well as harmonisation work on metadata, common features, data standards and common formats, harmonised declaration of compliance, and other issues, in relation to the Commission Delegated Regulations for ITS Directive priority actions. This chapter is based on the last NAP Annual Report (2020)[27].

6.2 NAPs in a European context

The basis of the National Access Points can be found in the so-called ITS Directive 2010/40 - Framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport. In this Directive six 'priority actions' have been defined, four of which have resulted in the Delegated Regulations mentioned above. Recently three more additional European policies have been adopted which support the further development of National Access Points in Europe.

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[25] The authors want to thank the following contributors to this chapter: Jacqueline Barr (IBI Group), Peter Lubrich (BASt), Mihai Niculescu (ITS Romania), Lars-Olof Hjärp (Swedish Transport Administration), Lucian Ilina (RNCRIA), Rui Gomes (Armis), Lígia Conceição (Armis), María Bernaldo de Quirós (Tekia-DGT), Laura Rey (Iceacsa-DGT).

[26] The Delegated Regulations can be found here:
- SSTP: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0885&from=EN
- SRTI: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0886&from=EN
- RTTI: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R0962&from=EN
- MMTIS: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R1926&from=EN

[27] https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/NAP/EU%20EIP%20-%20National%20Access%20Points%20-%20annual%20report%202020.pdf

The *EU Directive on open data and the re-use of public sector information*[28] was published in July 2019 and replaces the 2003 'Public Sector Information Directive'. Member States are encouraged to promote the creation of data based on the principle of 'open by design and by default'. The key changes include:

- High-value datasets, dynamic and real-time data, shall be made available via Application Programming Interfaces (APIs) and, where relevant, bulk download
- Limiting the exceptions allowing public bodies to charge more than marginal costs for the re-use of their PSI
- Bringing new types of public and publicly funded data into the scope, such as utility, transport and research data
- More transparency around public-private data arrangements, to create a more level playing field for all market players, promoting the use of standard licences

A significant number of the datasets covered by the ITS Delegated Regulations are expected to be considered as PSI and are already covered in NAPs. Article 9 of the new Open Data Directive sets out practical arrangements to facilitate finding data. Examples include the development of tools and online portals that make it easier for users to find and re-use data, and appropriately licensed metadata. Existing EU policies and NAP funded projects have made progress in portals, increasing data discoverability, metadata mapping and harmonised metadata catalogues, and it is anticipated that this new directive will build from these developments.

The *Strategy for a Sustainable and Smart Mobility*[29] was released on 9 December 2020 and supersedes the 2011 Transport White Paper as the European Commission's vision for transport. In order to reach the sustainability objectives of the European Green Deal action at EU level the Commission believe it is necessary to have efficient and strong initiatives that can deliver the needed climate and environmental impacts. The strategy sets a roadmap and clear policy framework for the sector towards the sustainable and digital transitions. It includes the following objectives:

- increasing the uptake of zero-emission vehicles
- making sustainable alternative solutions available to the public and businesses
- supporting digitalisation and automation
- improving connectivity and access

The Strategy also includes an action plan with a list of measures that the Commission will take to achieve the objectives of the strategy. From the Roadmap the following areas can be linked to NAP activities:

- digitalisation - generate business opportunities, innovation, new services and business models
- innovative mobility platforms – data driven, achieved through deeper integration and pooling a variety of different mobility services
- sustainable alternative fuels and associated infrastructure – alternative fuels NAP datasets
- block-chain and common databases – supporting large analytical query workloads

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[28] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L1024&from=EN

[29] https://transport.ec.europa.eu/transport-themes/mobility-strategy_en

The third policy is the *European strategy for data*[30], published in February 2020. It aims to create a single market for data that will boost Europe's global competitiveness and data laws. The Communication states that common European rules and efficient enforcement mechanisms should ensure that:

- data can flow within the EU and across sectors
- European rules and values, in particular: personal data protection, consumer protection legislation and competition law, are fully respected
- the rules for access to and use of data are fair, practical and clear, and there are clear and trustworthy data governance mechanisms in place; there is an open, but assertive approach to international data flows, based on European values

The actions of the strategy are based on four so-called 'pillars':

A. A cross-sectoral governance framework for data access and use

B. Enablers: Investments in data and strengthening Europe's capabilities and infrastructures for hosting, processing and using data, interoperability

C. Competences: Empowering individuals, investing in skills and in Small and Medium Enterprises

D. Common European data spaces in strategic sectors and domains of public interest.

The data strategy recognises that digitalisation and data play an increasing role in supporting transport sustainability and points out that several legislative frameworks already contain data-sharing obligations, establishing lists of transport related datasets. The strategy states that wide availability and use of data in public transport systems has the potential to make them more efficient, greener and customer friendly. For 'smart cities', data use to improve transport systems is also central. These activities are all supported by NAPs.

As noted in pillar D, the strategy will support the establishment of common European data spaces to ensure that more data becomes available for use in the economy and society. There will be a mobility data space, to further advance intelligent transport systems, including connected cars and other modes of transport. The data space will facilitate access, pooling and sharing of data from existing and future transport and mobility databases.

Most of the actions and developments have data related commonalities and are to be progressed between the end of 2020 and 2022, therefore NAP activities should maintain a watching brief and assess the implications and impacts when more detail becomes available.

6.3 Current status of NAP implementation

Based on the NAP survey conducted in 2020 it can be concluded that Member States are increasingly complying with the Commission Delegated Regulations for safe and secure truck parking ((EU) 885/2013), SRTI ((EU) 886/2013), RTTI ((EU) 2015/962) and MMTIS ((EU) 2017/1926). However, there are still quite a few countries that have work to do.

At the end of 2020 the following could be observed:

- Nineteen countries have an operational NAP for safe and secure truck parking and three countries have concrete plans to implement the NAP. The European NAP for safe and secure truck parking has truck parking data from only 12 countries, which means that not all data available in the National Access Points for safe and secure truck parking can also be found in the European Access Point. Only very few private parking operators provide

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[30] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en

data to the NAPs. Data providers are mostly public authorities and concessionaires. Only in Germany, the Netherlands and Spain there are several private organisations which provide data. In most cases there is not much information available about the number of organisations who use the data from the NAP: for Czech Republic there were 62 downloads from the EU truck parking portal (2019 figure), Poland reports 19 users, Denmark and France five users and Hungary four users of the NAP for truck parking.

- Twenty-three countries have an operational NAP for Safety-Related Traffic Information and three countries have concrete plans to implement a NAP for SRTI. 17 NAPs have data only supplied by public authorities (including concessionaires). Six NAPs (Denmark, Germany, Italy, Netherlands, Spain, Sweden) also have private data sources. Although there is an increase in the number of organisations that use the data from the NAP for SRTI, NAP operators still seem to pay little attention to monitoring the use of the NAPs. Thus, it is not clear to what extent Delegated Regulation 886/2013 has resulted in a wider use of SRTI.
- Twenty-three countries have an operational NAP for Real-Time Traffic Information. Another four countries have concrete plans to implement a NAP for RTTI. At least six out of 23 NAPs for RTTI also provide data from private parties. According to the Delegated Regulation (EU) 2015/962 for RTTI a National Body is not required. Nevertheless, 14 Member States have nominated a National Body and three are planning to do so. 11 countries will not nominate a National Body or don’t know yet.
- Sixteen Member States report a NAP for Multi Modal Travel Information Services, either fully or partially operational. Seven other Member States have concrete plans to start the implementation. Given the fact that the NAP for MMTIS not only covers main road network data but, for example, also data on urban road networks, multimodal data, cycling data and alternative fuel data, the role of road authorities in the implementation of MMTIS NAP is often limited to delivering part of the data (RTTI).

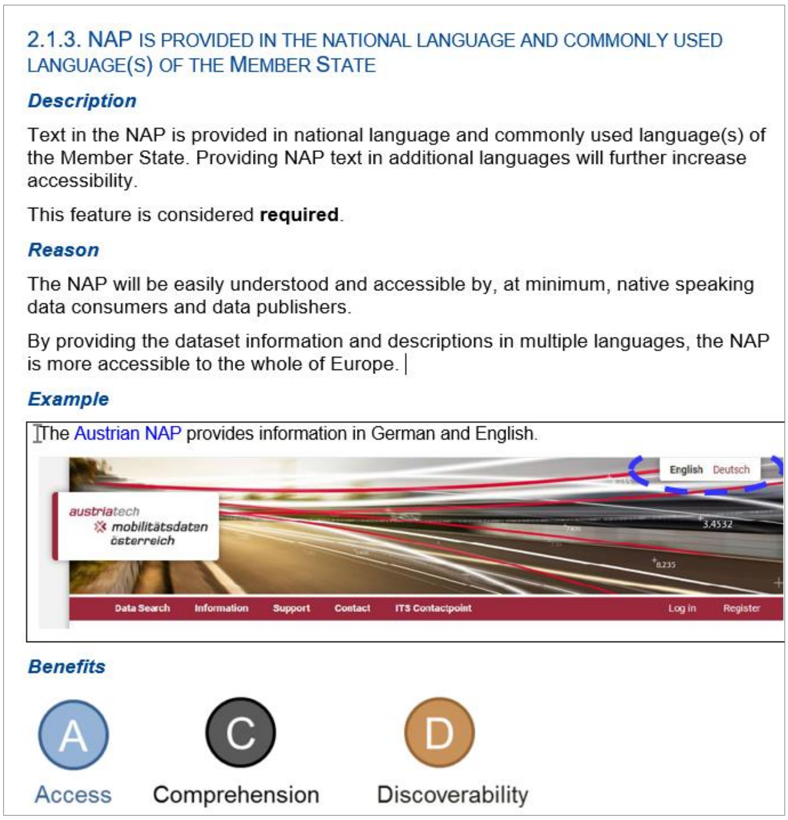
From the above it can be concluded that NAPs for safety-related and for real time traffic information are the most implemented NAPs, whereas the number of NAPs implemented for multimodal travel information services is significantly lower. An up-to-date overview of the existing NAPs in Europe can be found at the following link: http://andnet.ro/nap_eueip/.

6.4 Common features & Level of Service

The Delegated Regulations only state the obligation to establish NAPs for truck parking, safety related traffic information, real-time traffic information and multimodal travel information services. It does hardly prescribe any obligations on the features and level of service. This has resulted in a large variety of NAPs, using different structures, models, methods of data access / search tools and data checking methodologies. Therefore, the EU EIP project developed a set of features intended to support good practice, help make existing and future National Access Point services available to a wider audience, facilitate data sharing, and promote the discovery of datasets. The features are not mandatory and have no formal link to the Delegated Regulation of the ITS Directive. There are 20 features, grouped into five subsets:

1. Access – six features covering gaining access to the NAP and basic features
2. Communication – four features related to engaging with data consumers and publishers
3. Finding datasets – four features to facilitate data consumers need to find datasets they want
4. Update and maintenance – three features on ensuring information is current and the NAP is maintained
5. Dataset information – three features covering the additional dataset information that should be provided by the NAP

Each feature has a description, reasons for being included, examples, and benefits, see figure 6.1 below for an example. The features are described in the Support Document[31] and there is also a Features Checklist[32] for NAP implementers.



2.1.3. NAP IS PROVIDED IN THE NATIONAL LANGUAGE AND COMMONLY USED LANGUAGE(S) OF THE MEMBER STATE

Description

Text in the NAP is provided in national language and commonly used language(s) of the Member State. Providing NAP text in additional languages will further increase accessibility.

This feature is considered **required**.

Reason

The NAP will be easily understood and accessible by, at minimum, native speaking data consumers and data publishers.

By providing the dataset information and descriptions in multiple languages, the NAP is more accessible to the whole of Europe.

Example

The Austrian NAP provides information in German and English.

Benefits

Figure 6.1: Example Feature

Based on Member State feedback the focus of the future NAP feature developments and improvements are in the areas of compliance to web-design standards and accessibility, data protection and security, enhancing discovery services and (machine-readable) metadata.

6.5 Metadata

Metadata describes the administration, organisation, and content of a dataset and of a data service. Metadata datasets are therefore crucial elements to make NAPs accessible and searchable. There is a need to harmonise Metadata descriptions and structures for the following reasons:

1. to help to make data available and searchable for pan-European service providers
2. to ensure Metadata to be machine-readable in a later stage
3. to ensure a common understanding of the listed data content

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[31] https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/NAP/EU%20EIP%20-%20National%20Access%20Points%20-%20Common%20Features%20and%20LoS%20Support%20Document%20v2.0%20200810.pdf

[32] https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/NAP/EU%20EIP%20%20-%20NAP%20Features%20Checklist%202020.pdf

Metadata represent a recurring element of Delegated Regulations of the ITS Directive. Metadata have been mentioned in the Delegated Regulation (EU) 2015/962 for RTTI and in the Delegated Regulation (EU) 2017/1926 for MMTIS. It is recommended that Metadata should also have the same relevance for all other Delegated Regulations.

The Coordinated Metadata Catalogue[33] was established as a blueprint for NAP Metadata for each priority action of the EU ITS Directive. After a successful update of the Catalogue in 2019, with additional coverage of multi-modal travel data and services, according to Delegated Regulation (EU) 2017/1926 for MMTIS, the next step was to bring together the Metadata Catalogue with DCAT-AP, a well-established metadata specification in the domain of European Open Data portals, developed by a joint initiative of the EU organizations DG DIGIT, DG CONNECT and the EU Publications Office.

The result of this exercise is a "napDCAT-AP" extension, i.e. an adaptation of the DCAT-AP data model to meet the specific demands of NAPs, e.g. by adding NAP-specific model elements. "napDCAT-AP" will eventually foster interoperability of NAP metadata with, e.g. open data portals, and eventually allow findability of NAP data sets outside the NAP portals. The concept and draft of "napDCAT-AP" can now be downloaded from the EU EIP website[34]. Further work on "napDCAT-AP" will be carried out in the NAPCORE project (2021-2024).

6.6 Standards & common formats

All Delegated Regulations supplementing the ITS Directive refer to certain standards to be used when exchanging information with NAPs. While DATEX II is prevalent, the NeTEx CEN/TS 16614 and SIRI CEN/TS 15531 standards are also stated. This section summarizes the main standards and common formats relevant for the Delegated Regulations. In chapter 6 of the NAP 2020 Annual Report[35] more details can be found.

6.6.1 DATEX II

DATEX II was developed as a standardised solution to communicate and exchange traffic information among traffic centres, service providers and information broadcasting companies. The usage of DATEX II for data exchange is named in Delegated Regulations for safe and secure truck parking ((EU) 885/2013), SRTI ((EU) 886/2013), RTTI ((EU) 2015/962) and MMTIS ((EU) 2017/1926). However, common and harmonised recommended reference profiles or recommendations are only available to a limited extent, mainly for Delegated Regulation (EU) 885/2013 (safe and secure truck parking) and Delegated Regulation (EU) 886/2013 (SRTI) and to a lesser extent for Delegated Regulation (EU) 2015/962 (RTTI) and Delegated Regulation (EU) 2017/1926 (MMTIS).

The EU EIP – NAP survey of 2020 confirms an increase of the knowledge about DATEX II in national implementations. Compared to 2019, more countries have operational NAPs which contributes to an even better picture of the DATEX II, and other standards, usage of NAPs. A very positive conclusion is that some countries are already planning and working towards implementing DATEX II v3, the latest version of the standard.

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[33] https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/NAP/EU%20EIP_Coord.%20Metadata%20Catalogue_v2.0_191115.pdf

[34] https://www.its-platform.eu/achievement/monitoring-harmonisation-of-naps/

[35] https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/NAP/EU%20EIP%20-%20National%20Access%20Points%20-%20annual%20report%202020.pdf

6.6.2 NeTEx & SIRI standards

The *NeTEx* (Network Timetable Exchange) standard is a CEN standard (CEN TS 16614-1, 16614-2 and 16614-3) for exchanging public transport data, based on Transmodel (EN 12896-1 to 9), aiming at standardising the way of exchanging data between the information systems involved in public transport. It is based on open technologies (XML, XSD, and UML) and enables service operators and authorities to represent public transport data anywhere in Europe using common formats, standard rules, and uniform protocols. NeTEx is divided into three parts:

- Part 1: Network topology (CEN TS 16614-1)
- Part 2: Timing information and Scheduled Timetables (CEN TS 16614-2)
- Part 3: Description of the tariffs (CEN TS 16614-3)

SIRI (Service Interface for Real-time Information) defines a standard for exchanging dynamic public transport passenger information data in XML format. SIRI is divided into five parts:

- Part 1: describes the context and the framework
- Part 2: describes the communication infrastructures and mechanism to exchange real time information
- Part 3: specifies individual application interface of functional modules on real-time tables (production, estimated, at stop, for connection) or on monitoring of vehicles (position, travel time)
- Part 4: enables the exchange of information on the current status of available facilities (facility monitoring)
- Part 5: is linked with DATEX II to provide real-time information on situation and incident that appends along the road network, and which impacts the journey of the public transport vehicles

To give some simple examples, SIRI provides:

- real-time departure which could be different from the departure announced in the timetable provided by NeTEx
- real-time information about the position along the route to an individual vehicle
- synchronisation between arrival and departure to guarantee the connection if connections are needed for a journey

A SIRI-Lite version is also available which is a profile of SIRI to make it simpler to implement and deploy according to the usage of Representational state transfer (REST) than SIRI uses SOAP.

6.6.3 TAP - TSI

The Technical Specification for Interoperability on “Telematics Applications for Passengers” (TAP-TSI) of the trans-European rail system has been defined by Regulation 454/2011. These specifications are maintained by ERA, European union Agency for Railways. This agency is also responsible of the TAF-TSI which applies to freight transport by rail.

TAP TSI allows the harmonisation/standardisation of procedures, data and messages to be exchanged between the computer systems of the railway companies, of the infrastructure managers and of the tickets vendors in order to provide reliable information to passengers and to issue tickets for a journey on the European Union railway network, in accordance with Regulation n°1371/2007 on rail passengers rights and obligations. TAP – TSI can also be used in the context of urban rail systems. TAP – TSI prescribes protocols for the data exchange of timetables, fares / tariffs, reservations, information to passengers in station and vehicle area, train running information, etc.

6.6.4 Open Journey Planning (OJP)

The Open Journey Planning (OJP) API will allow a system to engineer just one interface that it can make available widely (to authorised users or openly as they so choose) rather than having to engineer separate APIs for each bipartite exchange arrangement that may be required with other systems. The principle of the OJP standard is based on a distributed journey planning. Two profiles are possible for a journey planner system:

1. Active: which receives the request from the traveller with origin and final destinations, analyses the possible routes, requests to each passive journey planner involved in the route calculation, collects and combines the responses from each of them and provides the responses to the traveller who choice his preferred route.
2. Passive: which receives the request of the active journey planner to calculate routes in its geographical area, transmits the responses to the active journey planner.

The basis of this standard is that the most relevant journey planner to provide the most accurate and updated information is the one which is operating closely to the public transport network. It limits the data collection and data update at centralised level to avoid risk of delay and big data exchange of unused data.

6.6.5 GTFS & GTFS-RT formats

TriMet in Portland worked with Google to format their transit data into an easily maintainable and consumable format that could be imported into Google Maps. This transit data format was originally known as the Google Transit Feed Specification (GTFS). GTFS provide the static information for the public transport network and timetable. As a result of developer innovation, GTFS data is now being used by a variety of third-party software applications for many different purposes, including trip planning, timetable creation, mobile data, data visualisation, accessibility, analysis tools for planning, and real-time information systems. In 2010, the GTFS format name was changed to the General Transit Feed Specification to accurately represent its use in many different applications outside of Google products.

Among public transportation data formats, GTFS stands out because it was conceived to meet specific, practical needs in communicating service information to passengers, not as an exhaustive vocabulary for managing operational details. It is designed to be relatively simple to create and read for both people and machines. Even organisations that work with highly detailed data internally using standards like NeTEx, use GTFS to publish data for wider consumption by software developers who are more familiar with the Android applications. GTFS-RT is the real-time data extension for GTFS. It can be translated in SIRI-Lite.

6.7 Case studies

Two case studies have been carried out to analyse the content and the ease of use of the NAPs in Europe. This is presented in the following paragraphs.

6.7.1 Case Study 1: Analysis of NAPs for Multimodal Travel Information Services

Across Europe, the MMTIS NAPs have been implemented individually by each Member State, according to the national regulations, resulting in different levels of development. For 16 countries the developments in the field of the implementation of NAPs for Multimodal Travel Information Services (MMTIS) have been identified, focusing on road traffic. In summary, some inconsistencies are identified in the implementation of the MMTIS NAPs by the different Member States:

- The integration and organization of the datasets on the NAP websites. Some MMTIS NAPs are a website repository with links redirecting to an external entity. Others are focused on a repository of metadata (e.g., Lithuania). Yet, some others are focused on providing a user interactive platform for trip planning.
- European nomenclature harmonization regarding data categories and contents in each MMTIS NAP, with common tags regarding modes of transport and data categories according to the Delegated Regulation (EU) 2017/1926 for MMTIS, would be helpful in uniforming the data access.
- The clarification of the end-user of the MTTIS NAPs: data user entities or passengers. Some NAPs are focused on being a repository of links or datasets. Others like Cyprus and Estonia are focused on the final user (i.e. a passenger) providing an interactive platform.
- European legal harmonization regarding licensing data usage. Some countries make a clear distinction between license and contract. Some ask for a signed agreement; others registering. Such differences might create barriers in the data access.
- Quality of data. It might be difficult to access and estimate the quality of the data since the organisation is the only responsible for making sure that the data corresponds to what is declared in the metadata specification. To maintain a high quality of data, NAPs are strongly instructing API connections to adjust any changes in the data.

The expectation is that the MMTIS regulation will give a boost in the provision of multimodal travel information in general. The data heterogeneity and gaps are blocking the process, with major efforts being still required to achieve the desired levels. There are still some problems to be addressed in the near future:

- the integration and organization of the datasets in the NAP websites
- European nomenclature harmonization regarding data categories and contents
- definition of the mode of transports
- the focus on end-user of the MTTIS NAPs (data user entities and/or passengers)
- European legal harmonization regarding licensing the data usage (no restrictions, license, and contracts, signed agreements, user registration)

Despite the availability of standards and the growing trend towards open data, in real life, a rather ugly picture is shown for data quality:

- Datasets have different information, different data attributes, different purposes, or incomplete data
- Datasets do not contain all the expected information
- Lack of accuracy where the information does not reflect the ‘true’ situation
- Lack of data versioning where a system may not be using the latest available data and is therefore at risk of misrepresenting the ‘live’ situation
- Lack of coherence, i.e. that the data is not compatible and internally consistent (e.g. a set of summer timetables and stops that are operated in the winter)
- Lack of compliance, i.e., that the data does not match the rules of the format

These are just to name a few issues with real data. There is also the stakeholders’ sensitivity associated with tariffs information and the issues and barriers faced by road operators and authorities.

The relevance of the aforementioned quality of data issues is also stressed in the report to the EP and Council on the implementation of the ITS Directive with analysis of MS reports, where it acknowledges the need “to assess the need for further action.” One strategy to bridge this gap is to focus on road-operators and authorities, helping them with guidelines and customized support, to “let them do the job” of uploading accurate data. In general, MMTIS NAPs are strongly advising API connections to immediately adjust any changes in the data.

Moreover, there is the issue of the costs of scaling up: providing sources of dynamic data (e.g. SIRI real-time feeds) or existing travel information services requires a supporting business model. Finally, even though cities and operators sometimes have their own continuously improved databases, which they have refined and corrected using much of their own resources and day-to-day operation knowledge, this data is very valuable and cannot be easily obtained from them.

6.7.2 Case Study 2: A data exercise in existing NAPs

Across Europe NAPs have different structures data warehouses, web portals, marketplaces, metadata registries. Users experience and feedback is very important for NAP operators. If NAPs are to help stimulate development of new data services and open up datasets to new data users, they need to meet user needs and expectations. Within the EU EIP project we have analysed the NAPs from Austria, Denmark, Germany, Italy, The Netherlands and Sweden on a number of aspects:

- How easy is it to search data in the NAP?
- Is it necessary/easy to register in the NAP to have access to the datasets?
- Is the metadata/datasets information easy to understand by the users (also with respect to language)?
- In which format/language the datasets are available?
- How can the data be used (API's, push/pull services)?

The exercise was carried out for the NAPs on Truck Parking and for information on 'temporary slippery road surface' and 'speed limits' in the NAPs on Safety Related Traffic Information. The conclusions of this exercise highlight the following pros and cons:

- In general NAPs have user friendly interfaces to facilitate search in the portal
- Most NAPs provide free information about data sets (without registration on the NAP platform) but the data sets are accessible only to users registered at the owner of the data sets. If registration is required, there are too many procedures and no information about the registration.
- Easy to search and find metadata. Most NAPs are at least in two languages (national language plus English, but not for all content).
- It is not always obvious how the data can be used. Some NAPs give an explanation, others do not.
- NAPs seem to have well-defined data security procedures

6.8 Conclusion

From 2013 to 2017 four Delegated Regulations have been adopted on the provision of traffic and travel information services (SSTP, SRTI, RTTI, MMTIS). Since then, Member States have started to implement National Access Points. The EU EIP project has monitored this development and it can be concluded that it has resulted in a scattered landscape of a wide variety of NAPs, ranging from simple registries to advanced marketplaces. Not all countries yet have fulfilled their obligations to set up the respective NAPs, but a clear positive trend is visible. And this this trend will be further strengthened by the NAPCORE[36] project and associated national developments.

This variety of NAPs has resulted in different structures, models, methods of data access / search tools and data checking methodologies. This is also clearly shown by two 'case studies'

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[36] NAPCORE website: http://www.napcore.eu

carried out by EU EIP, one focussing on MMTIS and the other focussing on Truck Parking and SRTI.

To harmonise NAPs and foster interoperability, the EU EIP project developed a set of NAP features intended to support good practice, help make existing and future National Access Point services available to a wider audience, facilitate data sharing, and promote the discovery of datasets. In addition, EU EIP produced a draft “napDCAT-AP” extension, i.e. an adaptation of the DCAT-AP data model to meet the specific demands of NAPs, e.g. by adding NAP-specific model elements. “napDCAT-AP” will eventually foster interoperability of NAP metadata with, e.g. open data portals, and eventually allow findability of NAP data sets outside the NAP portals. Finally, the EU EIP project also made an inventory of the most suitable standards to be applied in NAPs such as DATEX II, NeTEx, SIRI, TAP-TSI, OJP and GTFS(-RT). Finally, the EU EIP project developed Uniform Declarations of Compliance for (EU) 886/2013, SRTI, and (EU) 2015/962, RTTI, and (EU) 885/2013, STTP, to harmonise the so-called assessment of compliance process.

All topics mentioned above are described in much more detail in the NAP 2020 Annual report, which also includes some other topics like the NAP architecture and other relevant EU projects related to National Access Points.

7 Quality Frameworks for ITS services

Author: Peter Lubrich (Federal Highway Research Institute, BASt)[37]

7.1 Why do we deal with the Quality of European ITS Services and their Data?

A major driver for the quality work within EU EIP is that the efficiency and acceptance of ITS services heavily depend on (minimum) quality targets from the perspective of a traveller. Such services rely on data inputs from different data providers, so that there is a clear correlation between the quality of an ITS service and the underlying data.

The example in Figure 7.1 shows a typical quality issue in the context of road work information, being often integrated in traveller information portals. The same road work event is represented in two different information portals with an inconsistent localisation, i.e. the road work has different start and end points. The analysis of this particular case indicated that data generation and georeferencing methods play a role here. A consequence of such case may be that a road traveller does not trust a specific information portal due to inaccurate information. From an EU EIP point of view, such inconsistency should be detected and described under a dedicated quality criterion, in this example called “geographical accuracy”. In a second step, any quality issues should be tackled by the responsible actors, and further monitored via the mentioned quality criterion.

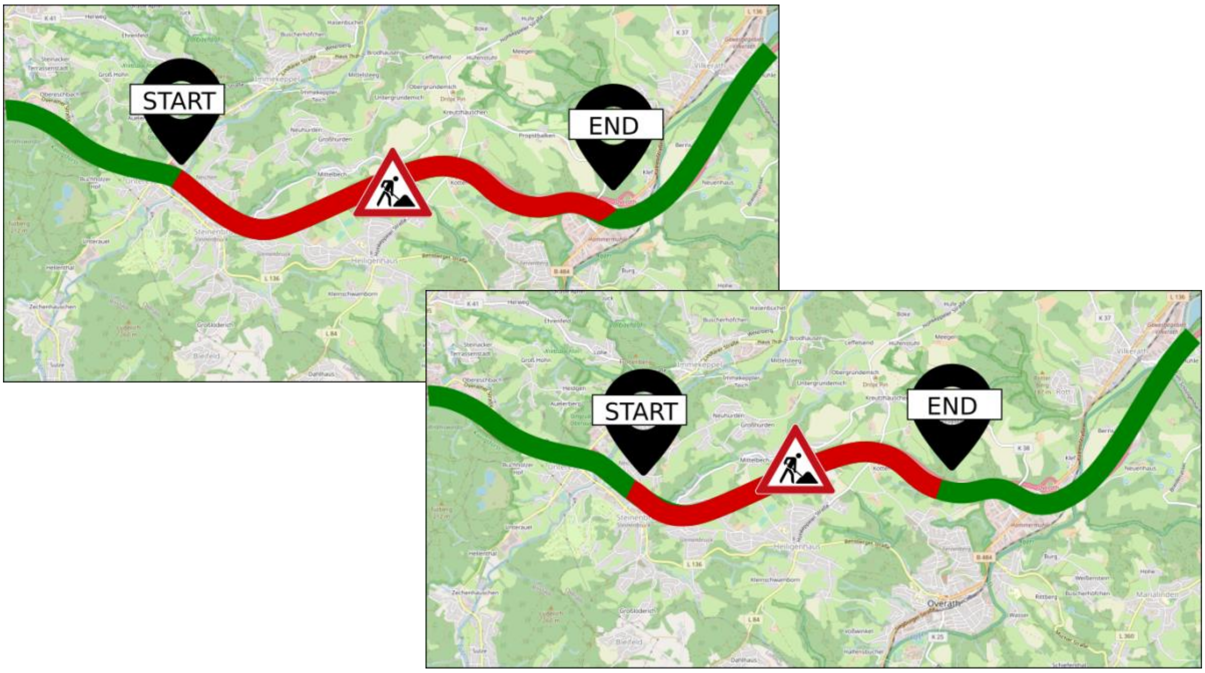

Figure 7.1: Example for inconstant localisation of road work information in different information portals (Map: ©OpenStreetMap contributors)

The example above becomes more relevant, when ITS services are built upon heterogeneous data offerings, from different data providers, different countries and different authorities. For

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[37] Other main authors of the EU EIP quality frameworks include Jacqueline Barr (IBI Group), Martin Jansen (Plannerstack), Tomi Laine (Strafica OY), Radu Milea (National Company For Road Infrastructure Administration), Mihai Niculescu (ITS Romania), Leif Rystrøm (Danish Road Directorate).

providers of ITS services, assessing and aligning the quality levels of such heterogenous data remains complicated and costly. To tackle this, the EC legal framework, namely the EC Delegated Regulations, not only stipulate the provision of ITS data, but also the documentation of data quality levels in the field of various ITS domains.

However, such stipulation assumes a common understanding of data quality. This is especially true for the Europe-wide deployment of ITS services, as well as the underlying data provision. In particular, there is a need for common quality criteria and requirements, as well as for quality assessment methods when evaluating ITS data and ITS services against the specified quality criteria and requirements. Before the EU EIP approach, as introduced in this chapter, there had been no agreed approach to define quality aspects among European ITS and data stakeholders in that manner.

7.2 The concept and Scope of the EU EIP Quality Packages

To address the quality issue, EU EIP sub-activity 4.1 elaborated a set of quality frameworks for several ITS data and service domains. These frameworks, called the Quality Packages, add quality aspects to parallel ITS implementation and pilot projects across Europe. Each Quality Package contains quality-related definitions and concepts, as proposed and agreed by EU EIP partners for the use in Europe. The definitions and concepts are based on evidence from conditions and operating environments in combination with the expert knowledge of the public and private stakeholders involved in the EU EIP quality work.

The target group of the Quality Packages are mainly data managers and data specialists at road operator organisations, as well as NAP stakeholders dealing with such data. This target group, however, had to be expanded during the EU EIP runtime to reflect the perspectives outside the road domain, for example in the multimodal context, as stated further below.

The scope of the quality definitions is restricted to ITS domains of traveller information, being a subcategory of ITS in general. These ITS domains also correspond to the priority actions of the EC ITS Directive, and the respective EC Delegated Regulations. Thus, the Quality Packages are established separately for selected ITS domains, each conducted in an iterative approach. Figure 7.2 shows the covered ITS domains and the iterative phases undertaken. It is evident that some ITS domains have been covered more deeply than others, resulting in an inconsistent maturity of each Quality Package. The maturity issue is discussed further below.

ITS Domain (EC Del. Reg.)	Quality Framework Stage					
	Take stock	Propose	Test	Validate	Enhance	Optimise
SRTI (886/2013)	✓	✓	✓	✓	✓	✓
RTTI (2015/962)	✓	✓	✓	✓	✓	✓
MMTIS (2017/1926)	✓	✓	✓	✓	✓	
Truck Parking (885/2013)	✓	✓	✓	✓		
C-ITS (n/a)	✓	✓	✓	✓		

Figure 7.2: EU EIP Quality Packages: covered ITS domains and iterative approach

The definitions in the Quality Packages further relate to certain parts of the so-called Value Chain of Traffic Information. The definitions focus on the content part of this value chain. The content part, which is typically in the responsibility of a data supplier, covers processes between the detection of a real event or a traffic situation until the provision of related information in a NAP. At a NAP, the traffic information is (typically) made available to many service providers via e.g. a data portal. The service provision, however, is out of scope of the work presented here.

Besides such Quality Packages, some side tasks explored the quality roles and actions in the evolving ITS ecosystem. One side task defined the relevant stakeholders, value chains, recommended work processes, when dealing with ITS quality. Another side task “Optimum Quality” examined optimisation aspects in terms of quality, from the perspective of European road authorities.

All deliverables from this EU EIP activity, including the individual Quality Packages and the accompanying documents, can be found on the EU EIP website[38].

Each Quality Package contains chapters on “Quality Criteria”, “Quality Requirements” and “Quality Assessment Methods. These build upon each other. Whereas “Quality Criteria” act as a baseline to define quality dimensions, these are then quantified via “Quality Requirements”. These two aspects are eventually put into a practical context via the “Assessment Methods”.

7.3 Quality Criteria

Quality Criteria are basic parameters to describe quality of ITS services and the related data. Usually, they are distinguished in the categories Level of Service (describing the provision of data) and Level of Quality (describing the data as such).

The data-related criteria are based on previous definition attempts, e.g. from ISO standards[39], but were tailored and adapted to the scope of EU EIP, as indicated above. They relate to temporal and spatial dimensions (e.g. “Latency”, “Location accuracy”), and the ground-truth correspondence of the data (e.g. “Error rate”). More generically, they give hints on whether and how information from a (virtual) ITS data provision corresponds with the (physical) environment, i.e. if there are any gaps or mismatches between data and reality.

7.3.1 Quality Requirements

Quality Requirements are understood as (minimum) quality levels to be reached by individual ITS services. These requirements specify at which (minimum) level the Quality Criteria should be realised by an individual ITS service to meet certain quality expectations. Such quality expectations are usually described in three levels:

* *Basic level*

** *Enhanced level*

*** *Advanced level*

The most important Quality Requirements are the minimum ones, denoted as the * *Basic level.* This level should be met by all services in all member states, because if the service would be provided at a lower level, the user benefits would likely be negligible or even negative. In addition to the * *Basic level*, tentative quality requirement recommendations are also given for an ** *Enhanced level* and an *** *Advanced level.*

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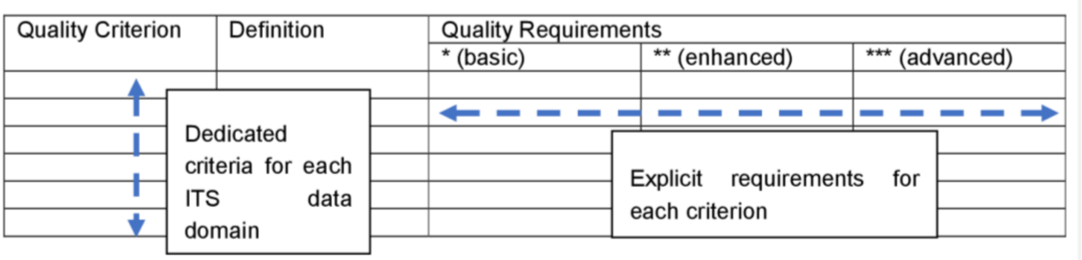
[38] https://www.its-platform.eu/achievement/quality-of-european-its-services-and-their-data

[39] ISO/TR 21707:2008, Intelligent transport systems -- Integrated transport information, management and control -- Data quality in ITS systems

The Quality Requirements are expressed in a quantitative way where possible. Depending on the maturity status of a Quality Package, they are understood as either initial values, still to be validated, or as already validated, i.e. proven in real-life conditions.

The Quality Requirements complement the Quality Criteria and are compiled in a tabular structure as shown in Figure 7.3.



Quality Criterion	Definition	Quality Requirements		
		* (basic)	** (enhanced)	*** (advanced)

Figure 7.3: EU EIP Quality Packages: Tabular structure for describing Quality Criteria and Quality Requirements

7.3.2 Quality Assessment Methods

These are potential methods for quality assurance and assessment. Usually, each Quality Package contains a set of proposed methods, each applicable for different uses and for studying different quality criteria. Typical methods include the monitoring of equipment performance and availability; reference testing (e.g. against ground-truth data), and surveys of perceived quality by data users.

7.4 Quality of Safety-Related and Real-Time Traffic Information Services (SRTI and RTTI)

The Quality Package for the domain of Safety-Related and Real-Time Traffic Information Services (SRTI and RTTI) was published in May 2019. It aims to support the SRTI and RTTI data provision in accordance with Commission Delegated Regulations (EU) No 2015/962 and No 886/2013.

This SRTI and RTTI Quality package is considered the most-mature product of EU EIP and its predecessor projects. It has undergone several updates and validations; consultations with NAP, SRTI and RTTI experts; and even national concretisations by selected road operators. The parallel validations were based on a series of quality tests with European partners, in order to evaluate and back up the quality definitions in the Quality Package.

Resulting from this process, the current version of the SRTI and RTTI Quality Package presents validated quality definitions, ready to be used in every-day practice by all SRTI and RTTI services and stakeholders in Europe. There is also an accompanying document “Practical Guidelines” which serves as a compact, hands-on guidance for quality practitioners, e.g. at Traffic Information Centres (TIC) or a Traffic Management Centres (TMC). Finally, the validation activities are also documented, providing references to recent quality tests in real-world conditions.

Altogether, the published set of documents shows the year-long efforts of EU EIP sub-activity 4.1 in establishing an agreed and validated framework for quality in the field of SRTI and RTTI.

As done for any EU EIP Quality Package, there was an intense involvement of SRTI/RTTI stakeholders, within and outside the EU EIP activity. The involvement allowed a reflection and (partially) revision of the quality definitions within the Quality Packages. A major stakeholder contribution came from road operators during the validation activities, where road operators participated in quality tests with real-life SRT/RTTI data. To do so, they provided sample data, assisted with data processing and helped to interpret the test results, in accordance with the EU EIP quality definitions.

As further stakeholders, SRTI/RTTI service providers were approached via the Traveller Information Services Association (TISA). One interesting notation from that group was that future quality frameworks should look beyond the content part of the information chain, being the current focus of the EU EIP work. Thus, the end-user perspective should also be considered, allowing a holistic quality approach among the entire information chain.

The production of the SRTI and RTTI Quality package further revealed some issues and challenges, one of them being the balance between details and universality. When providing many details and concretisations, the applicability of the quality definitions under different circumstances may be increased. On the other hand, the understandability of such definitions may be affected this way. For example, the table of quality criteria for SRTI and RTTI became quite complex during the years, including many remarks, exceptions and rules. In the end, the EU EIP group revisited these criteria again, cleaned them out and brought them to a more compact and universal level. This also better addresses the original goals of the Quality Package: to be a framework with common, EU-wide definitions, which need to be concretised at local institutions, for local circumstances.

7.5 Quality of Multimodal Travel Information Services (MMTIS)

The Quality Package for the domain of Multimodal Travel Information Services (MMTIS) was published in October 2019. It represents a first quality framework related to data and information in MMTIS and also aims to support the MMTIS data provision in accordance with Commission Delegated Regulation (EU) No 2017/1926.

As a starting point, the complex and multi-layered domain of multi-modal mobility was explored in terms of data and information quality. This was done via an extensive stakeholder consultation, in order to capture the individual insights and perspectives of MMTIS stakeholders. Especially for MMTIS, many diverse stakeholders are concerned, sometimes organised in branch organisations. The interaction included two stakeholder workshops and a structured questionnaire to validate the Quality Package. During this process, the stakeholders gave valuable feedback for the validation of the proposed MMTIS quality criteria, quality requirements and assessment methods. Interestingly, all criteria and most of the levels were agreed by the stakeholders, even if the individual quality perspectives and approach vary from stakeholder to stakeholder.

The stakeholder's inputs also revealed that there are already some individual quality concepts (including quality criteria and assessment methods) which could be incorporated in the EU EIP Quality Package.

However, the main lesson learned from the MMTIS quality activity is that quality assurance and assessment in MMTIS is far from being harmonised and widely established, certainly when it comes to door-to-door travel chains. Thus, the EU EIP Quality Package is a first approach for a common understanding on how to understand and handle MMTIS quality. However, further validation, research, and development efforts are required.

An essential challenge in this context, as identified in the validation phase, is that MMTIS quality is quite a complex and evolving working field. Expressed by the “Quality Iceberg” (see Figure 7.4), it becomes obvious that the visible part of data and service quality is a product of many underlying processes. Such underlying processes differ from organisation to organisation, and from data type and to data type, and are barely able to be harmonised in the form of a Quality Package.

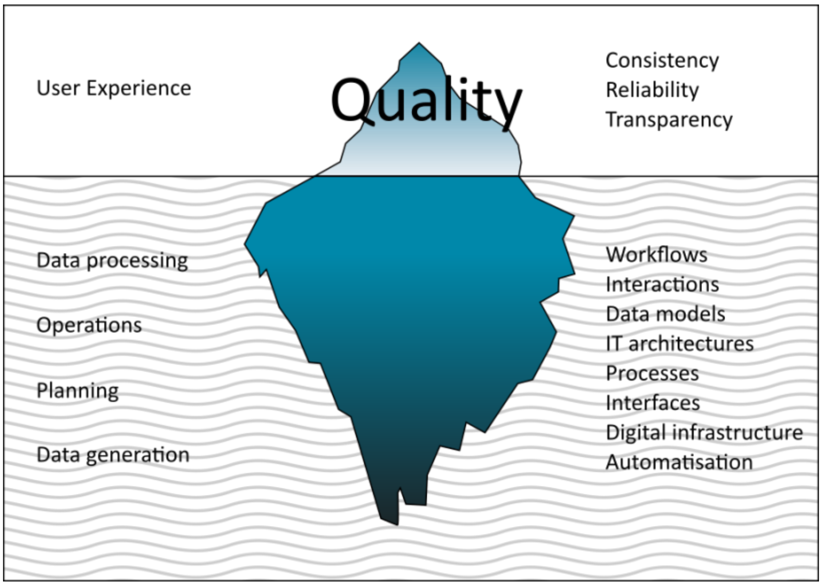


Figure 7.3: The "Quality Iceberg" in the context of MMTIS Quality (based on VDV, Association of German Transport Companies)

Altogether, MMTIS quality-related definitions cannot be determined in a complete and deep manner at this point of time. Consequently, the current MMTIS Quality Package is not considered a formal guideline, but more an aid or source of information for interested stakeholders.

7.6 Quality of Intelligent Truck Parking Services (ITPS)

The Quality Package for the domain of Intelligent Truck Parking Services (ITPS) was published in October 2019. It represents a first quality framework related to data and information in ITPS and also aims to support the ITPS data provision in accordance with Commission Delegated Regulation (EU) No 885/2013.

Some insights into the applicability of the current ITPS Quality Package could be derived from a validation phase, with focus on real-life ITPS data in the Netherlands and Germany. Both validations indicate that the definitions from the ITPS Quality Package are stable. i.e. the criteria can be replicated in real-life environments, and quality requirements seem to be at reasonable levels.

Again, relevant stakeholders were involved when drafting the ITPS Quality Package. During a workshop, questions were raised, e.g. whether the EU EIP quality definitions were sufficient for a common understanding on Truck Parking Information quality. Accordingly, data quality issues are important for the stakeholders, in terms of building a solid information base for the individual services. However, other issues seemed to be also important, such as the business perspectives of truck parking operators. It was stated that costs and benefits for delivering data (according to EC Regulations) do not always pay off. For the quality work, this means that the data perspective has to be put in a wider context, also reaching out to strategic and business goals of stakeholders in the ITPS domain.

The main lesson learned when defining quality criteria in ITPS is that many definitions from the former EU EIP quality frameworks could be adopted for the ITPS domain, so there was no need for developing such definitions from scratch in the ITPS case.

7.7 C-ITS Information Quality

The Quality Package for the domain of Cooperative ITS (C-ITS) was published in December 2020. It represents a draft quality framework related to data and information in C-ITS, and also aims to adds quality aspects to ongoing C-ITS harmonisation approaches in Europe, e.g. via the C-Roads project.

The main lesson learned from the elaboration of this Quality Package is that the variability of data categories and complexity of data flows in C-ITS deployments make a generic description of C-ITS quality quite challenging. Also, a pure adaption of the former Quality Packages, e.g. for SRTI/RTTI, would not be helpful.

To resolve this issue, the EU EIP activity started with a “zooming-in” approach, looking at selected communication chains and specific use cases. This way, some preliminary quality definitions were developed for those specific cases. The resulting Quality Criteria (e.g., “latency”) were then quantified with (minimum) requirements per use case. As evidence, e.g. from literature and evaluations of ongoing C-ITS projects, is still quite limited, only a few requirements could be quantified. In addition, the Quality Criteria were correlated with data elements from ETSI[40] specifications (defining message contents in C-ITS) as well as evaluation techniques in current C-ITS deployment projects.

Stakeholder inputs, collected in a recent workshop, indicated the need to differentiate the various C-ITS technologies, communication actors and use cases, when describing and defining Quality Criteria. For example, the choice of a specific communication technology clearly affects the definition and setting of many Quality Criteria. Such differentiation needs to be considered in future work on the C-ITS Quality Package.

The C-ITS quality work has been recently validated. Questionnaires were sent to C-ITS deployment experts, asking them to review the preliminary Quality Criteria. In the end, some of the definitions could be improved and reframed, and some practice-based recommendations were formulated to handle quality aspects in future C-ITS deployments.

7.8 Recommendations to road operators and NAP stakeholders

As road operators and NAP stakeholders are the main target groups of EU EIP, various recommendations to these groups have been derived from the work on the EU EIP Quality Packages. First, we need to sensitise each stakeholder when it comes to ITS data and service quality. Quite often, each stakeholder has some responsibility for a certain part of the communication chain or for certain data processes, and he or she may not know the consequences when the qualities are low. Thus, it is important to understand the entire life cycle of the corresponding data, to get an understanding of the value of the data to the end consumer. For example, when collecting road works data by a road operator and “entering” such data into a NAP data set, it is crucial to understand that service providers, and eventually road travellers, rely on a complete, accurate and up-to-date picture of roadworks in the network. In this sense, any data actor should know why the data has to be quality-assured. Second, there must be a regular and structured quality assurance (or quality control), embedded in every-day operations. This, of course, depends on the local and organisational set-up of data management. For example, different approaches may apply depending on the type of data sourcing. In the case of own data detection, e.g. via roadside detectors, failure detection and plausibility checks could be taken on. In the case of data acquisition from 3rd parties, e.g. via tendering procedures, quality assurance may be installed at the data provider,

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[40] ETSI: European Telecommunications Standards Institute

and be part of the contractual set-up. Further, concrete examples for commonly used methods are summarised in the EU EIP Quality Packages under the chapter “assessment methods”.

In any case, concrete outcomes of such quality assurance (or quality control) should be an explicit quality information, as an accompanying information to the data as such. Such quality information ideally should be expressed via the Quality Criteria according to the EU EIP Quality Packages. It should reflect how the current data provision and corresponding services meet the specified quality criteria, and allow comparisons, e.g. between different time frames and between different locations.

Eventually, such quality information about data offerings should be provided via a metadata entry in the NAP portal (e.g. as an explicit metadata field called “Quality information”). This way, a data provider will be able to describe the quality for his or her data offering in a transparent manner. In turn, a data consumer will be able to assess if and how the data offering meets his or her needs.

For regulatory bodies, it is recommended to provide clear guidelines and, more precisely, data profiles, concretising the provision of required data contents by data providers of the corresponding domain. Such profiles need to precise the handling of data models, as mentioned in the EC Delegated Regulations, e.g. for the DATEX II data model. When having common and agreed data profiles, quality definitions, such as those from EU EIP, could be easily related to such profiles. A positive example is the Guidance Documents by the EC for ITPS, accompanying Delegated Regulation (EU) No 885/2013, and clearly describing the data fields and DATEX II representation of required data contents.

Eventually, a more complete and more “obliging” state of ITS quality definitions is envisaged in the future. In this context, the application of the EU EIP Quality Package for SRTI/RTTI is explicitly mentioned in the draft for the planned revision of Commission Delegated Regulations (EU) No 2015/962.

7.9 Reflection and outlook

The presented work for the EU EIP Quality Packages indicates the value of having a European quality assurance and assessment framework in the domain of ITS. Besides the production of concrete frameworks, namely the mentioned Quality Packages, the work facilitated some fruitful discussions with many European stakeholders and experts on aspects of ITS data and service quality. Such discussions took place within the EU EIP group as well as with external stakeholders and organisations. During such discussions, it was often stipulated to apply or set up quality frameworks for the many ITS domains, e.g. for (multimodal) travel and traffic information services. The details and contents of such frameworks, however, require intense efforts to analyse the underlying data ecosystems, and to define and validate applicable quality concepts. These works have been carried out by EU EIP throughout the recent years and will be taken on by future EU projects.

The main lesson learned from the EU EIP activity is that any quality definition requires a continuous back-up and validation from stakeholders. For this reason, evidence from conditions and operating environments, as well as expert knowledge of the public and private stakeholders has been involved in the EU EIP quality work. Such back-up and validation resulted in several updates of the EU EIP Quality Packages. Thus, the most-recent versions, as published on the EU EIP website, reflect the current state-of-the-art of evidence and expertise regarding quality definitions for various ITS domains.

However, the various Quality Packages also reveal different levels of maturity. Whereas the SRTI / RTTI Quality Package is based on year-long experience and validation, the most-recent C-ITS Quality Package is fairly new, and thus lacks such maturity. Consequently, the work for establishing common ITS quality frameworks is an ongoing task, going beyond the run time of EU EIP.

Nowadays, the ITS world is faced with new technologies, increasing the range of potential data sources, data use cases and data actors, especially with regards to Connected and Automated Mobility. These technologies most likely will have a significant impact on ITS services, in particular traveller information services, e.g. by improving detection and communication of related data. As a result, we can expect significant potentials to improve achievable quality levels. However, these potentials cannot be completely described today. Thus, quality-related effects of near future technologies must be carefully analysed and eventually incorporated into the present quality frameworks.

In the new, EU-co-funded project NAPCORE, there is a follow-up activity, which will deepen and expand previous harmonisation efforts in the area of ITS data and service quality. As NAPCORE is all about the advancement and coordination of European NAPs, the goal of this quality activity is to monitor the quality of data assets on individual NAPs; to raise awareness of NAP stakeholders about NAP data quality aspects; and to provide guidance and support when dealing with such aspects.

In this context, NAPCORE will provide new, and enhance previous quality frameworks, looking at technological advances, as explained above. The project will also focus on the practical implementation of quality aspects in the responsibility of NAP actors, providing guidance and best practices for quality assessment. In this context, the needs of the so-called National Bodies will be also addressed. National Bodies are stipulated by the EC Delegated Regulations for NAP monitoring purposes on a national level, potentially also considering data quality aspects. Altogether, NAPCORE's vision is to deepen and further roll out previous harmonisation and support efforts on ITS data and service quality, as initiated by EU EIP.

8 TN-ITS Transport Network ITS Spatial Data Deployment Platform

Author: Ir. Frank Daems (ERTICO)

8.1 Introduction

The TN-ITS association[41], acting as an innovation platform under the legal umbrella of ERTICO[42], gathers all stakeholders to further develop the TN-ITS data sharing mechanism between (mainly public) pan European road authorities and service providers. This data sharing mechanism is based upon the Technical Specification CEN TS 17268 and already deployed via the CEF TN-ITS GO[43] project in 14 Member States.

One of the big benefits of this data feed is the ‘trust’ that applicants can have in this type of data, as it sourced from the public authority, acting as a trust provider (see ref[44]). The data enables the realisation of the ‘digital twin‘, building and maintaining a virtual representation of the physical roads, their attributes like traffic signs (e.g. speed limits). As such TN-ITS forms the basis for future regulatory type of data governing full automation.

In many cases, this data allows leading map and service providers to provide fresh, regularly updated, accurate, and trusted digital maps, e.g. deployed to OEMS and published in the in-car GNSS and navigation devices as a ‘base layer‘. This will be able to accept publications of all additional map related services as e.g. traffic management information (see the webinar: “How digital maps work”, September 2021[45])

TN-ITS is, together with DATEX II and public transport data, a pillar in the today’s European public mobility data space, accessible in todays and future deployed National Access Points (NAP), being organised by each member state.

The work of TN-ITS supports the Commission Delegated Regulation (EU) 2015/962 on RTTI, in particular the part of the Regulation that is concerned with static road data, i.e. data (and changes therein) that will generally be included in digital maps for ITS, for which TN-ITS closely cooperates with DG MOVE of the European Commission.

8.2 Background

The evolution of digital maps for ITS covers more than 30 years. It started in the second half of the 1980s with the large-coverage development by the commercial sector of detailed maps for navigation systems. These maps were based on the GDF standard[46], which developed in parallel. Soon after market introduction of navigation systems, in the mid-1990s, the digital maps started to be used for other ICT-based in-vehicle systems that were under development. These advanced driver assistance systems (ADAS) were followed by cooperative systems (C-ITS), and currently automated driving is on the horizon. The map in combination with

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[41] https://www.tn-its.eu

[42] https://www.ertico.com

[43] https://tn-its.eu/tn-its-go

[44] https://tn-its.eu/storage/uploads/documents/2020/10/22/TN-ITS-Reflection-paper-22102020.pdf

[45] Webinar how maps work: https://www.youtube.com/watch?v=-8XCrfeOFug&list=PL4LSYXNwsQOnxMckSlGJYiajh3LwWy_EH&index=6

[46] CEN TC 278, "Geographic Data Files" (GDF 3.0), draft European Standard (ENV), 12 October 1995, European Committee for Standardization (CEN), Brussels, Belgium.

positioning developed to a valuable sensor for in-vehicle systems. The navigation map providers developed into multinational organisations with the same map database specification world-wide, providing maps for ITS. Over time, with the successive generations of applications, the requirements for the map increased. It has especially become increasingly critical that ITS maps are highly up to date. The ITS map providers use many different data sources and uphold quality and freshness of their maps. But it is practically very difficult if not impossible to capture the many highly scattered changes that occur day by day in road attributes.

Road authorities decide on and implement these road network changes. It was realised already some ten years ago that adequate capturing and storage of changes in road attributes by road authorities, immediately when these occur, would constitute by far the most efficient and timely source for accurate information on such changes. Doing this would require adequate procedures at road authorities, and a road map database as data store. With progressing digitalisation, national road databases are also being developed. Solutions for the national road database will vary from country to country, in terms of specification, data model and GIS environment used. To overcome these differences, the TN-ITS framework was developed as a harmonised solution for exchange of ITS-related spatial data, and especially updates thereof. When organised well, with a solid cooperation between road authorities and ITS map providers, TN-ITS updates on road attributes will become a trusted source. In addition, it will concern single data points (not big data), which do not require extensive processing and interpretation.

TN-ITS is the Transport Network ITS Spatial Data Deployment Platform. The TN-ITS platform is organised as an association of members under ERTICO-ITS Europe. The mission of TN-ITS is to facilitate and foster, throughout Europe, the exchange of ITS-related spatial data between public road authorities as data providers, and ITS map providers and other parties as data users, in the context of the TN-ITS exchanges framework. Regular members are either data providers such as road authorities or data users such as the ITS map providers. Membership at the data provider side is generally at the national level, through the national road administration, ministry of transport or another national organisation involved in road data maintenance. Although membership of regional or local authorities is certainly possible. Any organisation interested in the activities of TN-ITS, but not qualifying as a regular member, may become a supporting member. Today, TN-ITS intends to expand its membership towards City and regional authorities, application and data providers

The TN-ITS exchange framework enables a data chain for timely provision of information on changes in road attributes and other elements of the physical road network infrastructure, including public transport elements and geometry, for inclusion in digital maps for ITS applications. The framework comprises of:

- collection and maintenance of road network spatial data at road authorities in an adequate digital map infrastructure and using adequate procedures,
- extraction at regular intervals of information on related changes,
- publication of such changes as sets of updates,
- implementation of the updates by ITS map providers in their digital maps, and
- provision of updates of ITS maps to end-users at similar regular intervals.

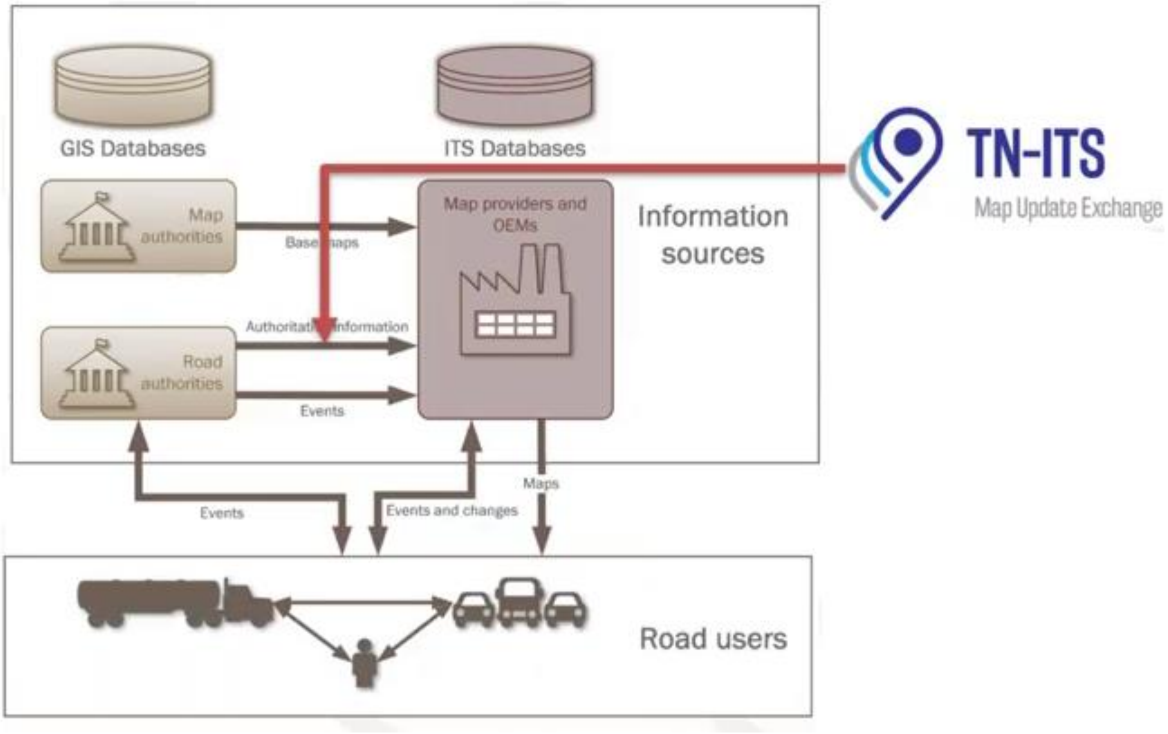

Figure 8.1: Parts of the flow of geospatial information in ITS, from Jetlund et al. 2019[47]

The framework builds the TN-ITS exchange specification, adequate methods for location referencing, quality control and feedback, a discovery service to find sets of updates, and on any further specifications or tools that may be developed.

8.3 Delegated Regulation 2015/962 and cooperation with DG MOVE

The work and mission of TN-ITS are closely connected to and support the implementation of the "Commission Delegated Regulation (EU) 2015/962 of 18 December 2014 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide real-time traffic information services"[48], published in the Official Journal of the European Union on 23-06-2015, with respect to Article 4 "Accessibility, exchange and re-use of static road data" and Article 8 "Updating static road data". For this matter, TN-ITS closely cooperates with DG MOVE of the European Commission. Conversely, the existence of the Delegated Regulation and the obligation concerning provision of static data arising therefrom for Member States significantly support the roll-out of the TN-ITS concept across Europe. Directive 2010/40/EU[49] is generally referred to as the "ITS Directive".

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[47] Jetlund, K., Onstein, E., Huang, L., Information Exchange between GIS and Geospatial ITS Databases Based on a Generic Model. ISPRS Int. J. Geo-Inf. 2019, 8(3), 141 https://www.mdpi.com/2220-9964/8/3/141. Retrieved 2021-06-23.

[48] European Parliament and the Council of the European Union, "Commission Delegated Regulation (EU) 2015/962 of 18 December 2014, supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide real-time traffic information services", published in the Official Journal of the European Union on 23 June 2015. Elaboration of "Specification B" as mentioned in the ITS Directive, and also referred to under this name.

[49] European Parliament and the Council of the European Union, "Directive 2010/40/EU on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other

The Delegated Regulation elaborates the Specification B as included in the ITS Directive. It should be emphasized that, while the name of the Delegated Regulation points to dynamic information, it also includes prescriptions for the provision of static data. The Regulation distinguishes two types of dynamic data: (1) "dynamic road status data" (road data that change often or on a regular basis and describe the status of the road); and (2) "traffic data" (data on road traffic characteristics). In addition, it defines "static road data" as road data that do not change often or on a regular basis. Static road data may also be understood as data changes which will be included in digital map databases for ITS applications. The use of the term "static" for data that sometimes change may be confusing, but the important distinguishing characteristic is the timescale at which changes do occur. The TN-ITS platform is involved with static road data, and indicates these 'static data' as 'Base layer map data'. For dynamic data, other communication channels and protocols are being used. The combination of both types of data in one Regulation highlights the importance of up-to-date and high-quality digital map data for the provision of dynamic information.

8.4 History

In 2009, the EC funded ROSATTE project produced the first technical specifications for the exchange of changes of (selected types of) road data[50]. These were used within the ROSATTE project to build, run and evaluate TN-ITS services in five countries in Europe, later by the JRC/EULF Transportation Pilot[51] which demonstrated the Norway-Sweden cross border compatibility of TN-ITS services, and finally by the CEF EU EIP A4.7 which continued deployment of (pilot) services in five EU countries.

eMaPS was the successor project of ROSATTE. Its objective was to revive the eSafety Digital Maps Working Group (later iMobility) and establish the ROSATTE Implementation Platform, which later, in 2013, became TN-ITS.

During the different pilot and operational deployment phases of services for sharing changes of road data, work group 2 (WG2) on the TN-ITS platform, set-up in 2013, led by the Norwegian Public Road Authorities, addressed standardisation and specification matters. It paved the way for the formal specification work which was started in June 2016 in WG7 of the CEN TC278 and who's effort was concluded in December 2018 leading to the publication CEN TS 17268:2018.

8.5 Role of the EU EIP action

The title of Sub-Activity 4.7 of the EU EIP project was "Provision of updates of ITS spatial road data" and was closely connected to the work of TN-ITS. The objectives of the sub-activity were the following

1. First basic TN-ITS implementation in each of the five Member States involved in this sub-activity, addressing a limited set of attributes, and addressing only the main corridors, to gain experience for future further roll-out of the service to the comprehensive network, and

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modes of transport", Brussels, 7 July 2010, published in the Official Journal of the European Union 6 August 2010. Generally referred to as the "ITS Directive".

[50] Wikström, L. (ed.), et al., "Specification of data exchange methods", ROSATTE Consortium, deliverable D31, version 16 (final), 31 August 2009. https://tn-its.eu/storage/uploads/documents/2018/09/02/ROSATTE-D31-Specification-of-data-exchange-methods-v16.pdf

[51] Transportation Pilot. "Improving accuracy in road safety data exchange for navigation systems". https://publications.jrc.ec.europa.eu/repository/handle/JRC104569

to get a thorough understanding how the service can be modelled in relation to the existing infrastructure for storing spatial road data

2. Identification of enhancements needed for the existing infrastructure to better accommodate the intended service
3. Investigation of existing procedures for the instantaneous updating of the stored spatial road data for changes in the real world, and proposals for improvement

The work of this Sub-activity concerned implementation of the TN-ITS exchange framework infrastructure in the five involved EU Member States: Finland, Flanders/Belgium, the United Kingdom, Ireland and France. In the pilot TN-ITS implementations were realised in Norway and Sweden, which are currently operational. It should be noted that each of the Member States had a different starting point. Finland was the most advanced and had already finalised its implementation by May 2016.

The TN-ITS sub-project started January 2016. The ITS map providers HERE and TomTom were again involved for testing their part of the data chain for each of the five Member States, as well as for advice, while TN-ITS (through ERTICO-ITS Europe) acted as the coordinator of the Sub-activity. The pilot also involved exploration of the use of INSPIRE data through the European Location Framework (ELF) platform, especially for solving difficult cases of TN-ITS updates in terms of failing interpretation of the location code in the update message. For this, the option to add an INSPIRE-based linear reference code to TN-ITS update transactions, to enable quick access in the originating map database for visual inspection of the local situation, was considered.

The EU EIP action has enabled TN-ITS to progress towards a pillar in the today's European public mobility data space, accessible in today's and future deployed National Access Points (NAP), being organised by each Member State.

8.6 Sub-Activity 4.7: TN-ITS and its advancement

In 2018, a project team of international experts in Data and ITS have advanced the then latest ROSATTE specifications into a CEN TS (called CEN TS 17268:2018). This TS reflects the actual TN-ITS base line.

The CEF project TN-ITS GO supported the TN-ITS platform work plan and its achievements. TN-ITS GO is a Programme Support Action (PSA) for the implementation and facilitation of seamless spatial data exchange which are essential for the deployment of ITS applications. The duration of the action is spread over 48 months, and ended in December 2021, in order to give time to an additional eight new Member States (Portugal, Spain, Slovenia, Hungary, The Netherlands, Greece, Lithuania, Cyprus) to carefully plan and implement their ITS spatial data supply chain strategy right from the source (police decision, road maintenance,...) all the way to the open TN-ITS interface and into the map database of the end user.

The Action capitalises on the pre-existing knowledge and expertise of the TN-ITS initiative which has already resulted in operational services in Sweden, Norway, Finland and Flanders. Other piloting efforts are ongoing in France, UK, and Ireland but these are not operationalised yet. It results in a total of 14 Member States deploying with TN-ITS services. Part of this action invests in these past efforts in order to further consolidate the operational services covering increasing parts of the TEN-T with the most relevant ITS attributes and increased quality. Also, the most advanced services will now work on the feedback loop from map makers to road operators which has not been tested so far. The exchange mechanisms put in place by the Member States is scalable and extensible to the whole network.

The WG 2 of the TN-ITS platform continues its role to maintain the CEN TS 17268:2018 governing the procedure for the TS change request:

- by its involvement in collecting and reviewing change requests from TN-ITS stakeholders
- by being an active member of the CEN TC278 W7 and other relevant standardisation bodies
- by governing the specification files as XML, XSD, WADL as well as the code list
- by providing documentation material as introduction texts, webinars, tutorials

TN-ITS WG2 also deploys the related UML model representing the reference specification implementation.

Figure 8.2: Evolution of the TN-ITS specifications

8.7 Near Future

The WG2 of the TN-ITS platform continues its role to maintain the CEN TS 17268:2018 by defining the procedure for the change request at the side of the platform, by its involvement in collecting change requests from TN-ITS stakeholders (mainly to support new functionality in the area of multimodality of transport, automated driving, etc.), by interacting with the CEN TC278 W7, and by governing the specification files as XML, XSD, WADL.

The TN-ITS platform supported the proposal for a National Access Point Coordination Organisation for Europe (NAPCORE[52]). The general objective of this action is to empower the National Access Points (NAPs) as the backbone for ITS digital infrastructure. It will facilitate national & EU-wide operational coordination for the harmonization and implementation of the European specifications. NAPCORE's specific objectives are to create a coordinated European mechanism of national access points based on coordinated governance and architecture, interoperability, standards, and services. It is based on the position paper of the NAP and National Bodies Harmonisation Group to strengthen the position and the role of NAP and to support steps towards the creation of European-wide solutions to facilitate the use of EU-wide data.

The proposed governance structure of the TN-ITS association and its relation to NAPCORE is shown below. The TN-ITS association is the executing body for the NAPCORE project, under the legal umbrella of ERTICO. The association itself organises its work in work groups. The several NAPCORE tasks are well fitted to the assignments of the workgroups. The NAPCORE project comprises tasks to be carried out with the help of the association's working groups.

NAPCORE provides the means to further develop on specifications, dissemination and awareness creation, providing assessments and insights to Member States and road authorities for further future potential implementation within EU Member States (Implementation being outside the scope of the NAPCORE project), insights in how to ensure

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[52] NAPCORE website: http://www.napcore.eu

TN-ITS data access via NAP integration, and enhancing data related aspects (as quality & accuracy control methodologies, maintaining trust along the data sharing chain ,…) .

However, the association also focusses on deployment and implementation of the services, including its implementation related necessary technical trainings and support. All activities carried out by the association, related to implementation of TN-ITS services are therefore out of scope of NAPCORE

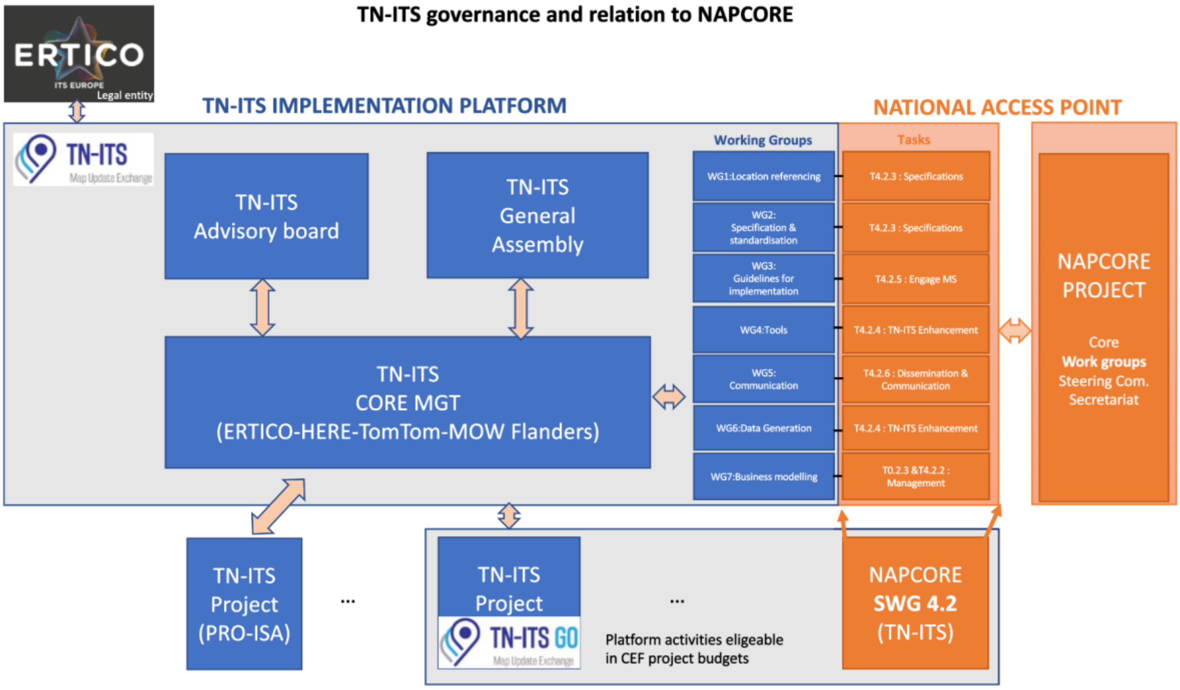

Figure 8.3: TN-ITS governance and relation to NAPCORE

8.8 Roadmap

TN-ITS platform intends to enlarge its geographical coverage by extending beyond TEN-T networks towards other roads, city and regional coverage. It continues to progress the specifications towards new road attributes, and it works on new technologies for data representation, such as 'Linked data', and data aspects, such as 'trust', data chain integrity, quality, accuracy, availability and accessibility.

The platform intends to expand its membership towards all new related actors in the mobility data space. The following picture shows each of the roadmap elements the TN-ITS platform takes into account.

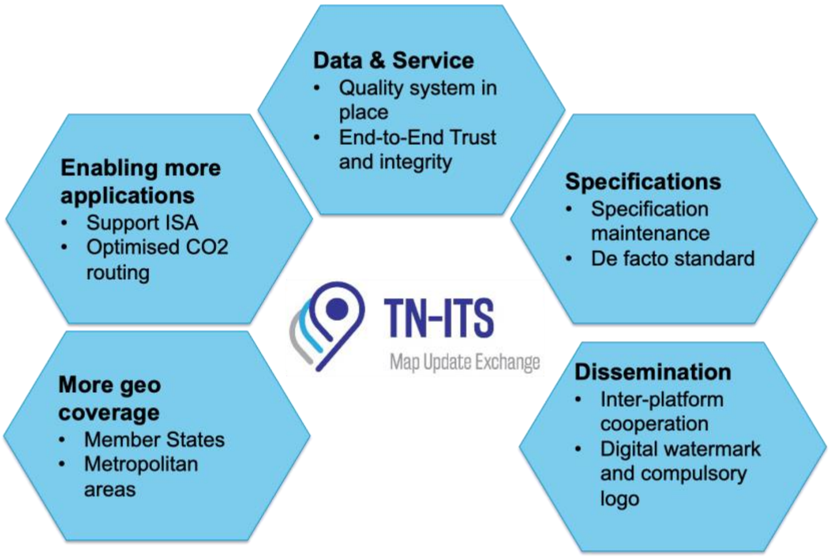

Figure 8.4: TN-ITS roadmap elements

An aggregated roadmap, in line with ERTICO's roadmaps[53], is shown in the figure below:

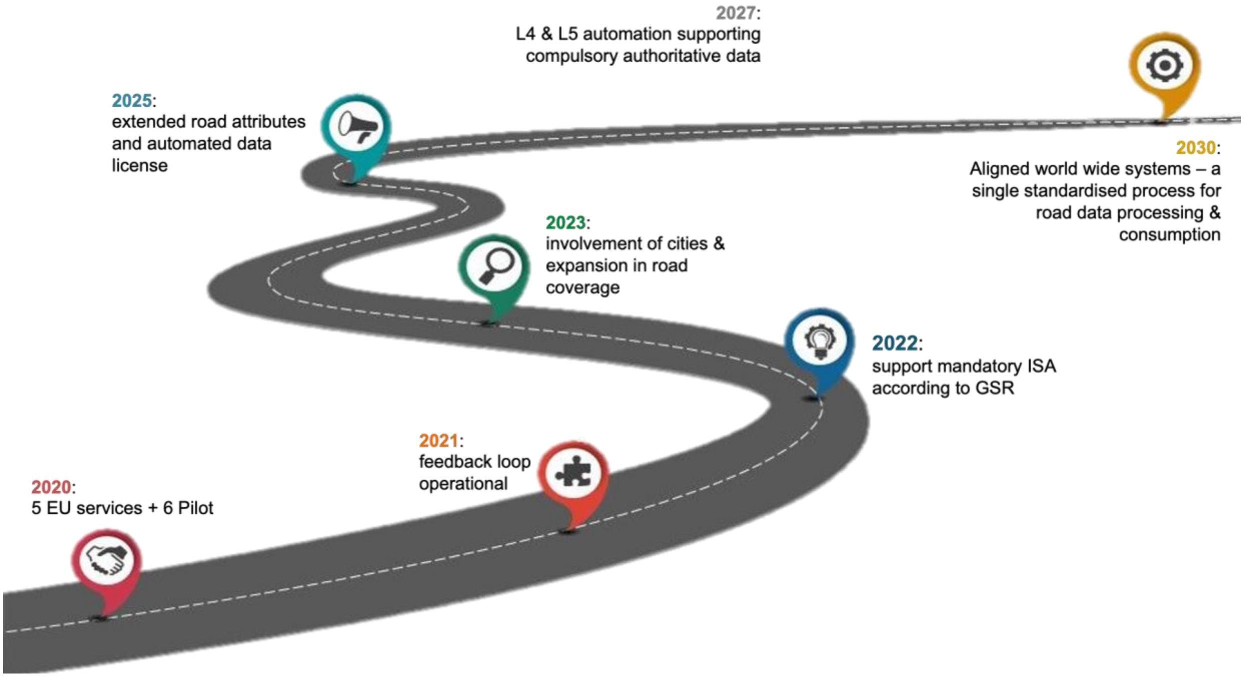

Figure 8.5: TN-ITS aggregated roadmap

The TN-ITS Platform is a dynamic organisation looking forward to fulfil the needs of advanced mobility applications such as Intelligent speed advice/adaptation (ISA) and Connected Automated Drive (CAD). Realisation of the roadmap is an important step to achieve this ambition.

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[53] https://ertico.com/focus-areas/connected-automated-driving/

9 ITS Deployment Roadmaps

Authors: Arne Lindeberg (Trafikverket), Jonas Sundberg (Sweco)

9.1 Introduction – ITS Roadmaps

Experience shows that plans and budgets made from national perspectives do not give a sufficiently high priority to multi-national cross-border investments, e.g. to equip European road corridors with the harmonised systems and services needed. Data driven innovation is hampered by lack of harmonisation and scattered development. Or, in short, the absence of a common strategic and long-term plan. Roadmap development offers methods for development of such plans, thus offering a possibility for European road operators to reach goals set.

Technology roadmaps related to ITS deployment have been developed for around 15 years, each roadmap with its specific planning objectives. Some examples are:

- EC ITS Roadmap Outline from 2007 addressing identification and implementation of Core ITS Services and how EC can support their broad implementation
- EasyWay ITS Deployment Roadmap (2009, updated 2012 and 2015) taking the EC roadmap further into a deployment plan for European road operators[54]
- The UNECE road map on ITS (2012, updated 2020) focusing on high level actions for integration of transport modes, improved road and transport safety and environmental impact from transport
- ERTRAC roadmaps on ITS, recent years (2017 and ongoing) with focus on connected and automated driving and urban mobility, proposing joint research actions including industrial development
- The Traffic Management Roadmap 2022 (2018) developed by Rijkswaterstaat (NL) focusing on specific applications within Traffic Management
- The MANTRA[55] (CEDR) roadmap (2020) "developing road operator core business utilising connectivity and automation" addressing requirements on road authorities to meet future connected mobility

Each of these roadmaps is made with specific objectives. Hence the multitude of ITS roadmaps does not mean work is duplicated, but planning needs to be done with a high level of detail within a limited scope.

In 2016-2020 the EU EIP project have developed an ITS Deployment roadmap with recommended actions for Core Network Corridor Digitalisation[56]. This work is highlighted in this chapter.

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[54] The EasyWay ITS Deployment Roadmap Reaching the Potential of ITS Through Coordinated Deployment of Core European Services

[55] https://www.mantra-research.eu/

[56] https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/ActionsForCNCDigitalisation/EU_EIP_4.3_D4_v1.0_210123.pdf

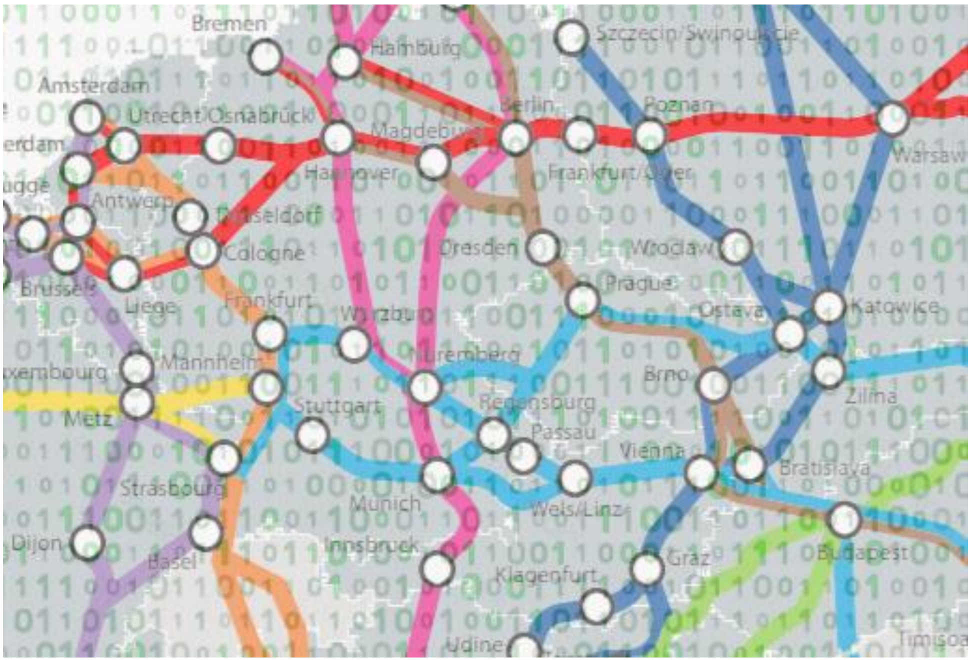

Figure 9.1: European Core Network Corridors with a digital overlay

9.2 A roadmap is a strategic planning tool based on knowledge and expectations

Roadmaps are strategic planning tools identifying actions needed to reach goals that have been set up. A roadmap shall be designed to describe the required process to reach specific goals and objectives. The narrower the objective, the more precise actions can be defined. The work process applied in e.g. the EU EIP ITS Deployment roadmap activity[57] can be summarised with the following steps:

- Define the goals, whether this is the introduction of automated driving or digitalisation of Core Network Corridors
- Clarify which systems and services that support this goal – what is the required add-on compared to today situation? (what)
- Identify and describe drivers that contribute to development and implementation of these systems and services in support of corridor performance (how)
- Assess the possible impact of these drivers
- Identify mechanisms that support the development of these drivers
- Clarify stakeholder responsibilities (who)
- Design a timeline for possible realisation of the needed development (when)
- Construct a roadmap combining the what, how, who and when

A roadmap is designed to lead to a future situation where goals have been achieved. Hence the roadmap should be built on knowledge as well as on a range of suppositions concerning forthcoming development. Important elements are, for example, insight in the current situation (including future needs related to care of legacy systems), expectations on future technical development and harmonisation, and assumptions concerning available financial resources in

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[57] EU EIP Sub-activity 4.3: https://www.its-platform.eu/activities/activity-4-harmonization-cluster/sa-4-3-its-deployment-road-map-update/

the future. Roadmap development thus requires a range of support activities establishing the knowledge needed. In this chapter we will look into some aspects of this knowledge building.

A good example is given in the next chapter (chapter 10) describing how a “leading innovation timeline” provided background knowledge to the “Traffic Management Roadmap 2022” developed by Rijkswaterstaat, the Dutch road authority. A similar method was used in the development of the EasyWay ITS Deployment Roadmap[58], where parallel development was made to establish Operating Environments (a harmonised road network description) and Deployment Guidelines (a description of harmonised service provision), both needed to support the roadmap development.

9.2.1 Drivers for ITS Innovation and Deployment

A technology roadmap relates to the environment in which the planned development is expected to take place. When dealing with ITS innovation and deployment, a range of factors will impact on the roadmap.

ITS deployment activities follow in general from five main driving forces. In most cases they act in combinations, and are not easily distinguished from each other:

- *Perceived transport system needs:*
  Most important are investments that are made in response to specific perceived local needs, e.g. solving problems at critical spots.
- *Transport policies put in place:*
  ITS deployment is also made in response to policies that are not directly related to local needs, e.g. road user charging systems are put in place to drive modal shift on a general basis in support of emission reduction, reduce congestion or simply to collect money to finance investments. Sometimes policies are expressed as legislation requiring ITS implementation. Such ITS would not have been implemented in the same manner without legislative support.
- *Technical development:*
  Also, technical development is in itself driving ITS deployment; new ITS are put in place simply because they have been made available, without fulfilling transport system needs or driving policies.
- *Organisational development:*
  Digitalisation and automation create opportunities for new groups of stakeholders and alliances between stakeholders. New systems and services open up for organisational and technical development. Providers of telecom and AI becomes involved in transport system development as the traditional role of infrastructure providers is changing.
- *Creation of business opportunities:*
  Several ITS are deployed on the basis that they generate better business for organisations, public as well as private. More efficient maintenance of roads, better load factor of lorries and passenger cars etc. Fleet management systems, ride-share opportunities etc. are examples hereof.

The strength in these driving forces is different and varies also over time. Whereas safety related measures have been in focus through history (as well in-vehicle as roadside), an increased need for efficient infrastructure use is coming up as a key driver, supported by digitalisation and automation.

9.2.2 Consideration to current situation

A very important driver behind ITS deployment is maintenance and upgrade of legacy (existing) systems. Such upgrades normally also include added functionality and service

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[58] https://www.its-platform.eu/wp-content/uploads/ITS-Platform/EUEIPBook/ITSDeploymentRoadmap_Deliverable_v1.pdf

improvements. Thus, to draw conclusions concerning possible investments in future ITS a picture of the expected requirements from maintaining and upgrading existing ITS is needed.

On the precondition that the implementation and operation of an ITS service has been found to bring value (like safety improvement, reduced congestion etc.), investments in ITS may be classified in four groups:

- They are made to implement new services on the network (e.g. the introduction of the first dynamic lane management system in a country or region)
- They are made to extend existing services to new parts of the road network (e.g. extension of a dynamic lane management system with additional 10 km in an urban region)
- They are made to replace old installations and equipment with new in order to safeguard operation (e.g. exchange of 5 year old roadside cameras or VMS panels that are dropping in reliability)
- They are made to upgrade existing systems with new functionality and new technology (e.g. exchange of VMS to graphic displays and adding new message icons)

The two last categories, which we can label as reinvestments, are difficult to distinguish from each other as improved functionality often follow from replacing equipment. Together they deal with legacy systems, i.e. the fact that the more ITS we put into operation, the more ITS will need maintenance and replacement and upgrade in due time. Legacy systems bind resources, as the more you have, the more resources will need to be reserved for their maintenance, upgrading etc.

In an EIP study[59] it was found that huge efforts will be required to keep “old systems up and running”, which limits the possibility to invest in new systems and services.

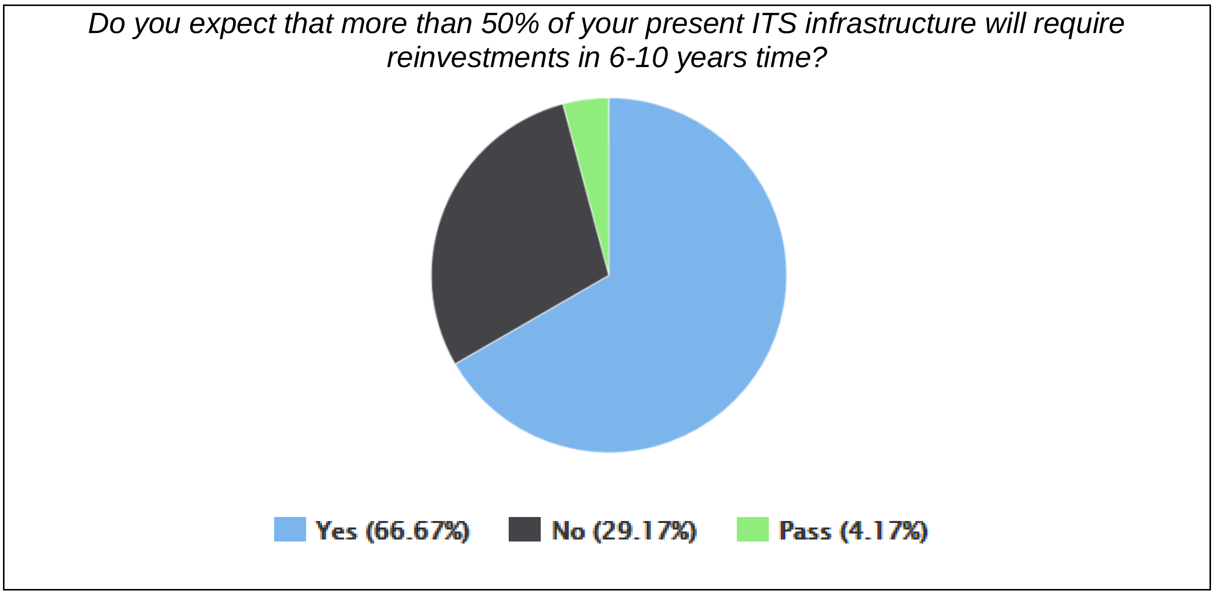

Figure 9.2: ITS reinvestment needs in Europe

The study also showed that this is most apparent in highly developed countries where maintenance of legacy system will cost approximately the same as new investments, in particular with a 6-10 year perspective.

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[59] European ITS Platform, Activity 5, 2015

9.3 Recommended Actions for Core Network Corridor (CNC) Digitalisation

The European ITS Platform, EU EIP, has through a specific task[60] investigated the challenges and opportunities to CNC digitalisation, and identified key actions that should be given high priority in development work ahead. Focus is on actions primarily addressing road transport and its intermodal connections and related to border crossings (institutional as well as physical), as they to their nature require institutional cooperation since no single stakeholder is a natural driver of development. Furthermore, the actions proposed are designed to be executed in a near future, before the end of 2025, and are based on the use of existing technologies. Together these actions form a roadmap for Core Network Corridor Digitalisation from a European road operator perspective.

9.3.1 Three characteristics of a digital Core Network Corridor – the goal

The basis for our selected actions is that a digital CNC is characterised by three characteristics which represents the target situation for the roadmap:

- *The driver, cargo and the vehicle experience a seamless transport system*
  The driver, the cargo and the vehicle systems do not experience "borders" along the transport route. Neither between geographical areas nor between transport modes. Systems and services are provided in accordance with the user needs and preferences.
- *Relevant stakeholders and organizations cooperate*
  Organisations that contribute to the development, delivery and operation of a digital CNC work together through established fora and formats where responsibilities are clearly defined and evolution is supported. As digitalisation contributes to a rapid growth in economy with new actors and new services, new business models and business relations will emerge based on common interests.
- *Data is always available*

  The key to a seamless transport system is accessibility to and availability of data. All relevant data must be available and accessible for all needs at any moment to any entity in the system, and business models for the supply and use of data shall be transparent and appropriate.

9.3.2 Suppositions concerning digital infrastructure

This roadmap is addressing a particular goal (above) with a road operator perspective. This means that it is based on a range of suppositions regarding development taking place outside the scope of the roadmap, notably by other actors than road operators. Here timeline studies provide important input.

This roadmap for Core Network Corridor digitalisation is based on a set of suppositions concerning the digital infrastructure in place. This influences upon the different roles of the actors in the system, and the actions needed.

- *The CNC´s will be covered by cellular radio*
  We can expect all road sections defined as part of a European Core Network Corridor to be well covered by cellular radio (4G, 5G). This coverage will be offered by (commercial) telecom operators. International roaming agreements will ensure that all vehicles with appropriate devices will be connected on the entire corridor.

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[60] EU EIP SA4.3 Deliverable 4: Recommended Actions for Core Network Corridors Digitalisation (see footnote 56).

- *Critical spots and road sections will have complementary ITS G5[61] coverage*
  Parts of the road network with very high usage and complex infrastructure, eventually also in association with specific ITS installations, will be equipped with roadside stations for ITS G5. We shall expect road operators to be responsible for these installations. There are also applications where vehicles communicate directly with other vehicles through use of ITS G5. A typical example is the application of Platooning which is highly relevant on CNCs.
- *Vehicles will be connected with their OEM (or associated organisation)*
  When a Heavy Good Vehicle is delivered for use, it starts immediately to communicate with its corresponding OEM for the purpose of remote monitoring and controlling vehicle functions etc. The data gathered constitute an important asset for the OEM for also other purposes than the operation of the specific vehicle.
- *New vehicles will have considerable autonomous capacity*
  We will for at least the next 20 years see a considerable mix of vehicles with different intelligence capacity on our roads. Vehicles with no digital capacity at all will mix with vehicles capable of self-drive. An obvious effect is that new vehicles get more advanced systems to monitor the situation around the vehicle. ADAS now include automatic brake, wild animal detection, 360^0 surround radar and cameras guided in all directions. Vehicles monitor road markings and read roadside signs with cameras.
- *Data will be collected through many sources*
  To support network operation, authorities have for several decades collected dynamic data from traffic. Following the introduction of third-party suppliers of in-vehicle ITS equipment, private companies (e.g. TomTom, Garmin) started to collect data with their introduction of navigation systems. This was picked up by application developers as the mobile telephone started to get in use (e.g. Google, Waze) and the development has continued. As the road vehicle has become more intelligent, the vehicle, through various sensors, now collect data for various purposes by a multitude of organisations.
- *Data from many sources will be combined by new actors*
  Road users, travellers or freight handlers, will have access to a large amount of applications offered by independent organisations that combine data from different sources into unique services. These applications will mainly support multi-modal solutions as their ability to combine information from different sources is their business offer.
- *Information exchange will use information clouds*
  A multitude of organisations (OEM´s, road operators, service providers of different kind) will continuously collect and process data for their own purposes but also consider that data constitute an asset if made available for other interests.

Hence, we will face a situation where a multitude of organisations will need to and want to exchange data on different conditions. In bi- or multilateral arrangements. The conditions for the data exchange depend on the value of the data for the parties concerned. There are different ways to organise such data exchange but following recent development, it is reasonable to expect cloud-based solutions emerging as the primary way to arrange exchange of data. As one information cloud to cover all organisations cannot be expected, we will see a network of interconnected (“federated”) information clouds in operation, and that Interchange operators will have a role to play similar to interconnection of telecom systems.

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[61] Including DSRC, 802.11p WiFi, …

9.4 Concluding recommended actions in the Roadmap for Core Network Corridor Digitalisation

When looking at the specific needs related to CNC digitalisation, we can assume a low level of urgency, thus the most efficient ways to generate development are to make funds available, make standards available, engage public actors (create policy interest) and to some extent engage commercial actors in the development (create business opportunities)[62]. This has been accounted for in the Actions definition provided in the following section.

9.4.1 Defining a short-term roadmap with a limited set of actions

We have identified a limited list of actions needed to digitalise Core Network Corridors. Our proposals are very much building on existing work and adding elements of organisation, harmonisation etc. Where similar efforts are already made or ongoing, we build further on these in detailed recommendations provided in our reports. We have chosen to make actions that also are enablers for more specific applications to be implemented.

Our time horizon is short: all proposed actions can start “now” and could be finalised within a maximum of five years.

Our action proposals are divided into three groups, which are described in the following paragraphs:

1. The first group include actions that builds needed organisational structures and common understanding
2. The second group relate to actions that provide the data needed
3. The third group include actions that provides access to data

9.4.2 Actions for stakeholder cooperation[63]

A common understanding of effects

European road authorities / operators shall have continued access to data enabling adequate assessment of costs and benefits related to ITS deployment, in particular concerning cross-border investments. To allow for benchmarking between CNCs and to ensure that the correct data is collected, a common view on suitable KPIs for CNC performance assessment constitutes a basis.

The action is similar to what is currently carried out by the ITS Corridor projects and EU EIP, where data from assessment of ITS deployment projects are compiled in accordance with common guidelines and results are compiled and published on a European level. The work will need to account also for new KPIs, e.g. related to a corridor perspective. Road authorities and road operators have to contribute with assessment data, and need to cooperate also on the compiled assessment. Also, organisations like CEDR and ASECAP are relevant as stakeholders. This action will clearly benefit from European support, but stakeholder own interest (policy interest) is an important driver.

Platforms and champions

No single organisation (beside the EC) governs the process of realising cross border digital transport corridors. Therefore several platforms, i.e. organisations for collaboration towards

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[62] See Deliverable 2: ITS Deployment Drivers, Incentives and other Mechanisms supporting ITS Deployments on Transport Corridors: https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/ActionsForCNCDigitalisation/EU_EIP_4.3_D2_v1.0_190228.pdf

[63] For a full description refer to Deliverable 4: Recommended Actions for Core Network Corridors Digitalisation (see footnote 56).

common goals, have been set up, each contributing by adding pieces to the work needed. There is a growing need for this ahead. A dedicated platform(s) committed to improve CNC performance through use of ITS applications shall be in place, and individual champions, usually twins, formal/political and informal/technical, shall have leading positions in the work within specific areas.

For CNC digitalisation it is recommended to combine efforts between CNC Coordinator offices and national road authorities / operators into a CNC Digitalisation Platform. Prominent stakeholders are as well European institutions (that benefit from the work done in platforms) as stakeholders that might fear missing out on influencing the process. Organisations like UITP, ASECAP, CEDR, ACEA, POLIS etc. are natural participants in ITS related platforms beside business and public partners. For the cause of CNC digitalisation, key stakeholders are Road operators and authorities mainly on the national level, similar to what is seen in e.g. EU EIP. Two typical, albeit quite different, models are given by the CCAM Platform and the EU EIP project whereas the latter includes considerable financial support (and co-funding by partners) in return for work done. In the CCAM platform both public and private parties participate. An interesting format concerning Champions is the assignment of Corridor Coordinators for the CNCs, with the role of pushing work forward.

9.4.3 Actions for common data

In addition to the actions proposed here, vast investments must be made in the physical part of the digital infrastructure: roads with sensor systems and their digital representation, communication infrastructure, management centres, mode interchange points and vehicles. These investments must be continuous for maintenance, operation and upgrades, and are essential in order to safeguard safety, fluidity and mobility on all roads at any time.

Service harmonisation

Users of the CNC shall perceive services provided as seamless in terms of content and interface.

The key element of the work will be to provide common (European) guidelines for service design regarding principles for user and vehicle interfaces (how), location (where) and provision of services (when) including quality definition and requirements. Supplementary well documented Best Practices will be a cornerstone in the work. As local adaptations will be needed, these guidelines shall function as voluntary harmonisation tools.

Public / National road authorities play a central role in this development as they have the responsibility on their respective road sections and a suitable format is a platform driven development. The ITS Corridor projects and their cooperation through the EU EIP platform is a good example of a suitable organisation. Development and piloting of solutions will require European financial support, e.g. through the CEF programme, since this is not a research activity.

The Road Corridor Information Document (Road CID)

The Road CID is a structured way of describing CNC´s. It contains descriptions of the general structure of the corridor, including network overview and organisations concerned. It describes how the traffic management centres are structured and their corresponding areas, and which ITS services (with focus on services relevant for corridor operation like HGV parking) are available and where TMP´s are in operation and how they connect. Hence the Road CID provides the reader/user with an understanding of the general structure of traffic management on the corridor level. Each CNC shall develop a Road Corridor Information Document and establish an organisation / solution for the continued management of this document. “Document” shall be understood as a suitable form for management and distribution of the information contained, hence it may be a website etc.

Public / National road authorities have to play a central role in the Road CID development. In particular as they will have the full responsibility to ensure completeness and correctness of information supplied. Also, European institutions through the Corridor Coordinator offices, have a strong interest and should be engaged in the work. Possible further actors are CEDR and ASECAP. Development and piloting of solutions will require European financial support, e.g. through the CEF programme. In the end, regulation may be needed to ensure that countries provide the information required in the agreed format through the agreed channels.

Geo-localisation and geofencing

European road operators / authorities need an agreed method to define Operational Design Domains (ODD) for the purpose of traffic regulation and operation. In particular considering future generations of self-driving vehicles, e.g. where certain levels of automated driving are allowed and where not, and electric mobility, e.g. where are use of fossil fuels not allowed.

Much of the needed basis seems to be available (e.g. through standards[5] and the INSPIRE directive specifications), but development of specifications are essential in order to establish operational implementations (profiles) of the standards when available. Following this, tests and pilot activities have to be carried out involving OEM´s and Public / National Road Authorities. European institutions must engage and take a strong position in the initial phase. Possible complementary actors are CEN, CEDR, EC, ASECAP, ACEA (OEM´s). Development and piloting of solutions will require European financial support, e.g. through the CEF programme.

Digital traffic regulations

Traffic regulations and other forms of restrictions or guidance that are needed for a driver / vehicle to perform in accordance with rules set when driving, including on road sections of the CNC, have to be available in real time in a known digital format through a known interface.

Standards are needed as a base[64] but also specifications are essential to establish operational implementations (profiles) of the standards when available. Tests and pilot activities have to be carried out involving OEM´s, national and local authorities etc. For this public/national authorities have to play a central role in the development. And as the need is European, European institutions must engage and take a strong position in the initial phase where possible actors are CEDR, EC, ASECAP, ACEA, POLIS etc. Development and piloting of solutions will require European financial support, e.g. through the CEF programme, since this is not a research activity.

9.4.4 Action for data availability

There is a need for integrated information management. The action aims at establishing data standards (standard profiles) to ensure that data is correctly interpreted, and the quality level is known. The action will also cover business aspects including information on which data is available where and on which conditions, in support of integration. Building on the framework of current and future amended ITS legislation, the action can be seen to extend the proposed initiative for a project aiming at federating National Access Points.

Stakeholders are primarily found among organisations with a strong business interest in data management and provision. Service providers like TomTom and Here, OEM´s and data warehouses are evident stakeholders but they will have also to provide their data in the NAPs.

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[64] CEN TC278 WG17 Urban ITS: https://standards.cencenelec.eu/dyn/www/f?p=205:7:0::::FSP_ORG_ID:2047388&cs=1059511000E67F15C4F1B553DFC62DD24

Also experts in high speed commercial data exchange like Ericsson and Vodafone are relevant. Data owners, including service providers, national road authorities have an important role to play. Development and piloting of solutions will require European financial support, e.g. through a Framework Programme project.

10 Leading Innovation Timeline as Enabler for Traffic Management Roadmaps

Authors: Louis Hendriks (Rijkswaterstaat), Ronald Jorna (Mobycon)

10.1 Introduction

Traffic management is changing fast. To make the right choices concerning smart mobility, it is important for road operators to monitor ITS developments relevant for traffic management. Dutch road operator Rijkswaterstaat developed a so-called Leading Innovation Timeline (LIT) to deal with this. It is a tool to visualize future innovation, particularly changes in IT systems which are expected to have an impact on traffic management. The LIT helps to create awareness of what is happening around us and how fast it will influence traffic management. When relying on the LIT, investments can be made in a timely manner. It also allows road operators to better assess the opportunities and risks of new innovations. This chapter starts with an overview of technological and societal trends, followed by a description of the Leading Innovation Timeline and how it can be developed further at a European scale.

10.2 Trends and developments

Several technological and societal trends and developments can be observed which are relevant to traffic management:

- Technological: traffic management is changing fast, with a future of ‘connected systems’ and ‘connected people’:
    - Connected: around 2020 all new vehicles will be equipped with wifi-p
    - Big data: Increasing amount of data available, also from vehicles
    - Artificial Intelligence: more and better insight in traffic as a system
    - Sensoring: new smart and cheap methods to collect data
    - Automation/robotisation: possibility to have processes without human intervention

  These are being facilitated through an increasing cooperation between public and private actors. The glue between these systems is the sensor data coming from all vehicles (floating vehicle data) and the distribution of public and private data to the end-users. The result is one integrated transport system with smart infrastructure and smart vehicles. This change will not happen overnight. It is not clear what will change, when it will happen and how it will impact traffic management. Uncertainty about these changes makes it difficult for road operators to anticipate on these changes. This particularly holds true for the introduction of automated vehicles: it is expected that it will be at least 2045 before half of new vehicles are autonomous, and not until 2060 before half of the vehicle fleet is autonomous[65].
- Societal: Smart mobility is defined as the (combination of) innovations which will make the organization of mobility better and cheaper. It is seen as an important means to cope with a series of societal developments:
    - Economic growth and continuing urbanisation are expected to lead to more congestion within and around cities. In a densely populated country as the Netherlands, expanding the infrastructure is not (always) possible.

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[65] Autonomous Vehicle Implementation Predictions, Implications for Transport Planning. By Todd Litman, Victoria Transport Policy Institute. August 2021.

- After years of improved road safety, progress in reducing EU-wide road fatality rates has stagnated in recent years[66].
- The climate goals from the Paris Climate Agreement request the reduction of CO2, also from mobility.
- At this moment, not all urban areas fulfil the requirements concerning air quality. A better mix of the various transport modes would increase the liveability of cities.
- The costs of maintaining, replacement and renovation are increasing. The means however are limited, which makes it more important to control these costs.
- Smart mobility is seen as a means to contribute significantly to achieve the societal goals in the domain of liveability, safety and congestion[67]. At the same time, it could bring down the public expenditure for the current systems.

10.3 Monitoring ITS developments: innovations and S-curves

In order to make the right choices concerning smart mobility, it is important for road operators to monitor the (expected) ITS developments relevant for the management of the road network. Not only for the short term, but also for the medium and longer term.

The long-term goals give direction to road operators. At the same time, it is also important to be flexible, since it is unknown how fast developments will go. However, based on current knowledge it is possible to distinguish three phases:

1. Start-up phase: Until 2020 it was about learning by doing, to prepare for the large transitions and in particular to realize quick wins for the short-term in accessibility and safety.
2. Scaling-up phase: From 2020 to approximately 2045 it is all about market introduction of autonomous driving and connected services.
3. Transition phase: After 2045 until approximately 2060 autonomous vehicles and especially connected services will change mobility in such a way that new technologies will start to replace old working methods.

A long transition period is ahead of us, in which changes will happen gradually. This means that at this moment road operators have to shape the future, whereas at the same time they have to do the daily operation of traffic management for a long period. The combination of connected and not-connected, autonomous and not-autonomous vehicles, will lead to increased complexity in traffic, certainly until 2040. The risk exists that this will negatively influence safety and congestion. Road operators have to prepare themselves for this risk. Flexibility means that road operators will have to take into account the possibility that some developments will go faster, others might be delayed, and new innovations will appear. In practice, this means that road operators will have to do two things:

1. The innovation process: strengthening the professional innovation chain through cooperation with, among others, the automotive sector, license agency, research institutes.
2. Monitoring: intensifying the monitoring of the “S-curves” and tipping points. Typically, questions to be answered are:
    a) Which technology is the ‘winning’ technology?

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[66] Commission staff working document, EU Road Safety Policy Framework 2021-2030 - Next steps towards "Vision Zero" (2019): https://visaozero2030.pt/wp-content/uploads/EU_Road_Safety_Policy_Framework_2021-2030_Next_Steps_towards_Vision_Zero.pdf

[67] Rijkswaterstaat. (2017). Position Paper Smart Mobility.

b) What does the S-curve look like, in which year will the impact on traffic management occur?

c) Which roles/actions come with it for road operators?

These insights will be leading for the speed and direction of smart mobility projects to be carried out by road operators. With the S-curve for innovation the development of the innovation over time is linked to the penetration ratio. It helps road operators to assess when an innovation will actually enter the market and when it will have an impact on traffic management. At a certain point in time the impact becomes such that a tipping point develops where the innovation will start to replace existing systems. To monitor the (changes in) S-curves is very important. Example: Such a tipping point is already almost there for Variable Message Signs, since the majority of road users already has an in-car navigation system.

To tackle these fast-approaching changes and developments, Rijkswaterstaat, the road operator of the national road network in the Netherlands, has developed a so-called Leading Innovation Timeline (LIT).

10.4 Leading Innovation Timeline

The Leading Innovation Timeline (LIT) is a tool to visualize future innovation, more in particular changes in IT systems which are expected to have an impact on traffic management. Based on literature research and meetings with experts of Rijkswaterstaat and external experts, technological innovations relevant for traffic management are mapped on a timeline until 2035. It not only shows the year when the innovation will become commercially available on the market, but also the year in which the first serious impact on traffic is expected. This is schematically shown in figure 10.1 below.

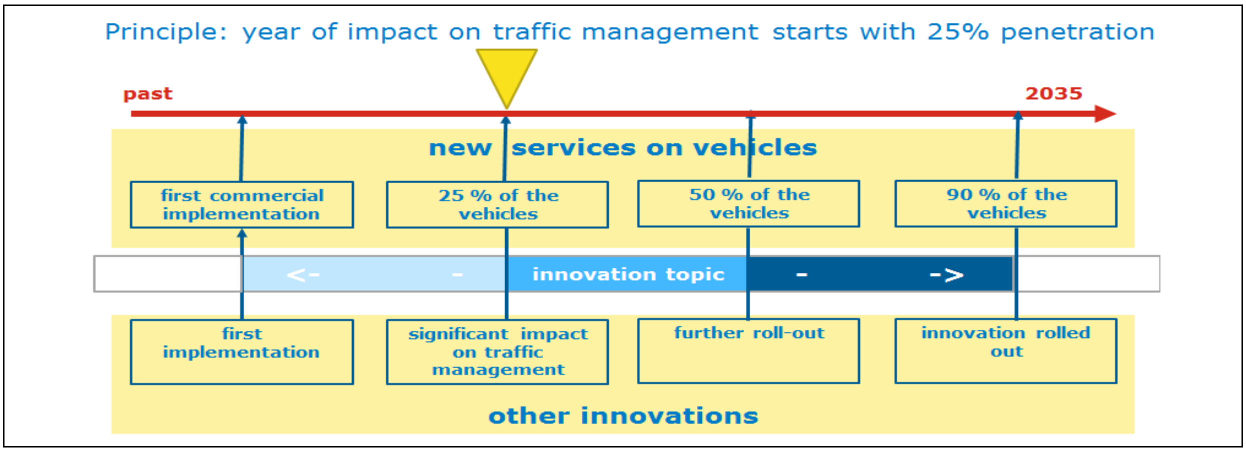

Figure 10.1: New technologies and penetration ratio

When all innovations are thus plotted on the timeline, it serves as a very good input for discussion on the effects and timing of the technological innovations, the role of the road operator and the tasks of its personnel (knowledge) with respect to traffic management.

The Leading Innovation Timeline distinguishes 10 categories of ICT developments:

1. Autonomous vehicle level
2. Vehicle – Vehicle level (V2V)
3. Infrastructure – Vehicle level (I2V)
4. Infrastructure level
5. Data transmission
6. Data services
7. Other

8. C-ITS day 1.0 services[68]
9. C-ITS day 1.5 services
10. SAE levels for automated driving

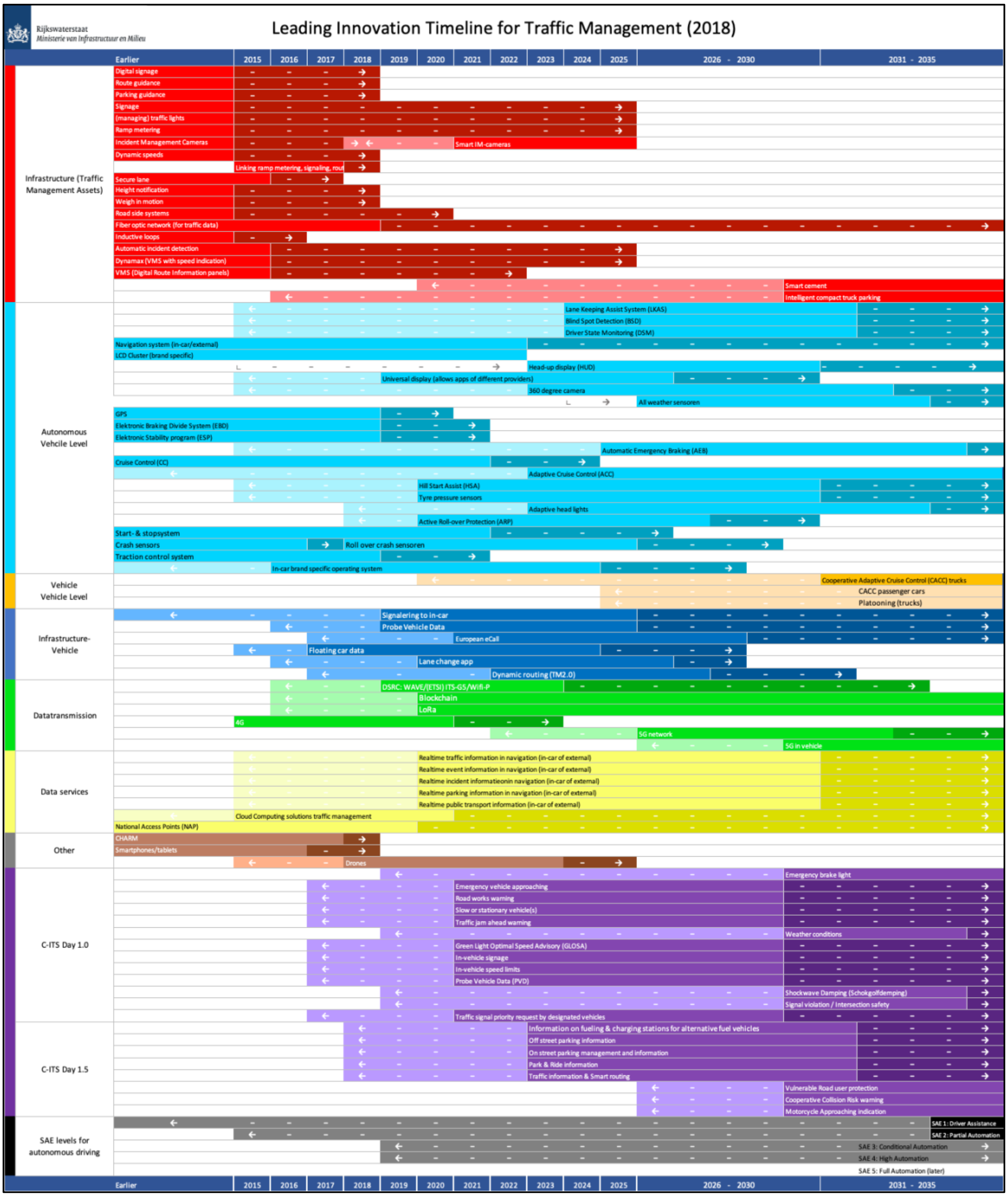

Figure 10.2: Summary of Leading Innovation Timeline (2018) in one page

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[68] The deployment of C-ITS is an evolutionary process that starts with the less complex use cases. These are referred to as "Day-1-services". More complex services are referred to as "Day-1,5-services" or "Day-2-services".

The first Leading Innovation Timeline was published by Rijkswaterstaat in 2015. It gave great support to enlarge awareness about what was happing regarding innovations. In 2016 the Timeline was updated[69], and the new version showed that the installed base for traffic management would be needed much longer then was foreseen. In 2016, C-ITS was added to the timeline as it became clear (by the EC report) what was really meant by the term C-ITS. In 2017 and 2018 the Timeline was introduced and incorporated into to the European ITS Platform. Figure 10.2 on the previous page shows the summary of the Leading Innovation Timeline in a single page.

This timeline is accompanied by a text document called ‘Central Document’: Leading Innovation Timeline For Traffic Management. This document briefly describes all topics and indicates for each topic the impact on road safety, traffic flow and environment. Distinction between passenger and/or freight traffic is indicated as well (where applicable). Each topic shows a list of relevant background documents with more in-depth information on the topic.

So far almost a hundred experts have given their judgement on which a topic should be included and in which year the first impact (25% penetration) is expected. It appears that the Leading Innovation Timeline is a good tool for discussions to gain better insight on what will/could happen and when it will happen.

In general, services are the result of a combination of technological innovations. One single innovation often has no impact on traffic or traffic management, but a combination of technological innovations (a service) does. The development of a service is dependent on the development of a number of technological innovations. These innovations, as well as the impact they can have on traffic and traffic management, can be visualized in the LIT.

Once these expected developments are known, road operators can identify the urgency to take action. Innovations with a relatively high impact in the short term require instant action (research, pilot, new strategy), whereas innovations on the long term and/or with little impact do not (yet) require action. This is shown in figure 10.3 below. However, in all cases the innovations need to be monitored constantly.

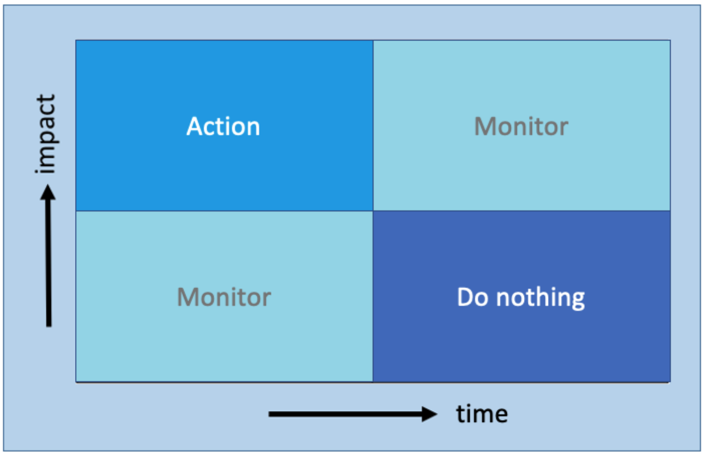

Figure 10.3: Impact and time aspect of innovations

10.5 Leading Innovation Timeline as input for European road operators’ policy

Increasing mobility in Europe is exacerbating traffic congestion on the European motorway network. The reduction of the number of accidents is slowing down. At the same time, due to developments such as smart electric cars for example, the composition of traffic is changing,

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[69] Rijkswaterstaat (2016). Leading Innovation Timeline for Traffic Management – version 2016.

data streams are growing, there are a multitude of technical innovations and road users are changing their behaviour. The Traffic Management Roadmap 2022[70] gives this transition substance. It defines ambitions for road traffic management, describes how Rijkswaterstaat can adapt to continue adding as much societal value as possible to traffic management in the future. It introduces seven network services that make up road traffic management and discusses improvement and renewal of these network services:

- Object Control
- Incident Management
- Road Works
- De-Icing
- Enforcement
- Network Optimisation
- Travel and Route Information

The renewal/transition of traffic management is based on four themes or tracks:

- Exchanging and Using Data (e.g., data from others);
- Developing Assets (e.g., smarter roadside systems);
- Influencing the behaviour of road users;
- Cooperating with partners.

While the roadmap mainly describes why certain choices are made and what ambitions Rijkswaterstaat is aiming towards, the “how” will need to be determined in the coming period.

The Dutch Traffic Management Roadmap 2022 is a great example of how the LIT helps provide input for policy and decision makers to define the next steps in traffic management. The LIT helps create awareness of what is happening around us and how fast it will influence traffic management. From the perspective of a road operator, those innovations that are expected to impact traffic management within a relatively short period (±5 years) are more relevant than innovations that are to happen at a later stage and are still unclear. This means that while the roadmap does include “Object Control”, “Incident Management” and “Road Works” as network services, it does not include “Automated driving” as this development is still too far away, too general, and not yet useable in day-to-day operations. The LIT supports the process of defining what innovations will affect traffic management and therefore helps to define what a road operator should focus on in the coming years.

The LIT also helps Rijkswaterstaat to gain more knowledge of innovations in traffic management. This knowledge is necessary when such innovations start affecting traffic management and the road operator’s organization has to change in order to keep up with new methods and systems. For example, when Floating Car Data (FCD) was introduced, public private partnerships were set up to be able to purchase and collect FCD instead of gathering data via loops. As the LIT allows road operators to be better informed of upcoming innovations that will affect traffic management, investments can be made in a timely manner. It also allows road operators to better assess risks that come with new innovations.

Below, two considerations are given with respect to expected developments that will influence the way road operators should maintain existing, and at the same time invest in new, ITS systems and services to further showcase the usefulness of the LIT in policy and decision making.

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[70] Rijkswaterstaat (2018). Traffic Management Roadmap 2022 – improving network services based on Smart Mobility.

10.6 Mixed fleet

Even though the speed of technological development goes fast, the impact on traffic is largely dependent on the level of penetration of the technology in the vehicles. Connected and autonomous vehicles are developing fast, but due to the long lifespan of cars, changes on the street will go much slower. This is an important observation, which will impact the way road operators will have to ensure road safety and efficient traffic flow. For example, the characteristics of the car fleet will partly block a fast and disruptive change:

- There are (approximately) 8 million vehicles in the Netherlands
- Every year approximately 400.000 new vehicles are being sold
- The average car is over 9 years old
- Because of the high quality of new cars, it is expected that new cars will even last longer
- Given the above, it will take approximately 20 years to almost replace the complete car fleet

This means that, assuming a strong growth of autonomous vehicles (level 4) starting from 2020, in 2040 approximately 30 to 50% of the car fleet will be more or less autonomous. This implies that manufacturer-based innovations of in-car systems will lead to a long transition phase with a mixed fleet. A nearly permanent situation will arise in which increasingly smart, autonomous vehicles will mix with largely conventional vehicles. This will lead to unexpected effects, also with impact on safety and congestion. For Rijkswaterstaat this means that conventional safety and traffic management measures will have to be maintained, while at the same time developing new measures.

10.7 Investment bump

In a wider perspective, other innovations like mobility services such as Uber and Snappcar[71] can have a much faster growth and thus also a bigger impact on mobility behaviour. Also, one can imagine that autonomous or driving task supporting systems will see a fast growth in leased cars. The gain in safety and productivity of employees will lead to a positive business case, even if the initial costs are high. Smart mobility services via smart phones (with a safe interface) can assist drivers in making better choices, even when the car is not ‘connected’. It is unlikely that more advanced systems (autonomous, ADAS) can be retrofitted cheaply and safely in existing fleets. It is also not very likely that all applications will improve safety and reduce congestion. Possible negative impacts (e.g., distraction of drivers, bigger distance between autonomous vehicles) need to be pre-empted.

The challenge of road operators is to facilitate the ingrowth of smart mobility with all possible support, while at the same time facilitating conventional traffic with the same safety level. In the long term, smart mobility will lead to a reduction of costs (through phasing out of current technologies). This transition period will lead to a ‘bump’ in costs, because on the one hand ‘current’ systems will have to be maintained, while on the other hand new systems will be developed and implemented. For example, Rijkswaterstaat expects that roadside systems will be required for the years to come. For cooperative and autonomous functionalities, the roadside systems will be replaced by roadside systems ‘light’. Rijkswaterstaat expects that promotion of good individual navigation will lead to a better follow-up of route advices and thus to a reduction in congestion and higher driver satisfaction. Navigation systems will be able to take over the role of Variable Message Signs, certainly for regular and planned situations (door to door, tailor-made message for individual users).

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[71] Snappcar is a company that provides a rental service of privately owned cars in The Netherlands, Denmark, Germany and Sweden.

10.8 Working towards a European Leading Innovation Timeline

The Leading Innovation Timeline is a useful instrument to monitor the expected technological developments from the perspective of the road traffic manager. It shows the expected timeline of technological developments as well as the expected impact of these technologies on traffic. It thus forms a good basis for road operators like Rijkswaterstaat to develop a long-term strategy for traffic management in Europe.

Where the LIT 2015 and LIT 2016 were mainly based on input from the Netherlands, the LIT 2018 already has some more European input. This broadened perspective has been achieved because the LIT is now part of the European ITS Platform (www.its-platform.eu). The European ITS Platform, or EU EIP, is a group of European road authorities and road operators aiming at the harmonised implementation of ITS on the main European motorways in Europe. It therefore is the perfect body to collect input and feedback on the expected impact of new technological developments, as well as to verify the LIT via experts in the field of traffic management.

However, broadening the timeline to the European perspective involves several challenges. While innovations are not country specific, the speed with which an innovation is implemented and accepted by road users or road operators is. One could for example distinguish between early adopters and followers. How should these differences be incorporated in a European timeline? The rate at which countries can implement new innovations also depends on the type of technologies that are currently implemented and when these need to be renewed. Implementing a new technology when the legacy systems have to be replaced anyway is relatively easy and cheap. However, a road operator may think twice about implementing a new system when the currently implemented system is relatively new.

In the coming years the EU EIP team is planning to work on how to address these challenges so that a European LIT can be developed that can help facilitate discussions, provide support for policy and decision makers, and can be used as input for other European traffic management road maps. Practitioners and academics from across Europe are welcome to use the LIT and/or to provide feedback.

11 Automation of Road Operators’ Traffic Management Centres

Author: Mihai NICULESCU (ITS Romania)[72]

11.1 Introduction – ITS Roadmaps

One of the activities carried out in EU EIP was to identify the requirements of automating the road operators´ ITS systems to facilitate automated vehicle – infrastructure integration. This included the roadside ITS systems with properties like self-maintenance, self-optimisation, self-management, self-healing fully or partly based on specific needs. These properties would evolve the TMCs towards autonomic systems that can make decisions on their own to achieve high-level system goals set by human operators.

The term autonomic is a biological metaphor adopted by IBM[73] to describe the desired properties of future complex IT systems, proposed as a highly advanced approach to deal with the problems of the delivery and maintenance of increasingly complex systems. Autonomic systems embody self-assessment and self-management abilities that enable the system to assess its own state, then adapt or heal itself in response to that assessment. The interface between system and owner is set at a very high level: the owner sets out goals, policies or service levels that the system must follow, and the system translates these into its system functions resulting in a change of behaviour. IBM defines four areas of autonomic functions: (i) self-configuration through automatic configuration of components; (ii) self-healing through automatic discovery, and correction of faults; (iii) self-optimisation through automatic monitoring and control of resources to ensure the optimal functioning with respect to the defined requirements; and (iv) self-protection through proactive identification and protection from arbitrary attacks.

The implementation of autonomic functions in the operations of traffic management centres could bring important benefits in increasing their efficiency and performance. The main reasons are the decrease of workload for the operators and, by processing large amounts of relevant data and the potential to find better solutions than a human operator. An autonomic system should be designed to have self-* properties[74] as a whole, not only at the level of individual components / subsystems.

The authors believe that to achieve these benefits, traffic centres should consider at least four high-level autonomic functions:

- self-management
- self-optimising
- self-healing
- self-configuration

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[72] The author wants to thank the following contributors to this chapter: Petri Antola (Finnish Transport Infrastructure Agency); Risto Kulmala (Traficon Ltd); Jessica Rausch (Hessen Mobil); Stephanie Cheung (Hessen Mobil); Susanne Schulz (Hessen Mobil); Maarten Amelink (Rijkswaterstaat); Laura Rey (ICEACSA); Jacqueline Barr (IBI Group); Xavier Daura Albeldo (Autopistas); Petri Antola (Finnish Transport Infrastructure Agency); Jonathan Siegfried (Hessen Mobil).

[73] An architectural blueprint for autonomic computing - http://www-03.ibm.com/autonomic/pdfs/AC%20Blueprint%20White%20Paper%20V7.pdf

[74] Self-* properties refer to any properties or processes of a system which are caused and maintained by the system itself.

In addition, the following supporting autonomic functions should be considered:

- self-learning
- self-diagnostic

The self-management function describes a system that is able to decide automatically how to react and plan the traffic management actions. One example could be that, in case an incident is detected, the system decides how to present and what information to show to the operator so that it is most relevant and most helpful for her/him to take action.

Self-optimising is another key function for an autonomic system. It defines a system that, given certain requirements, can automatically find the best solutions for a certain situation. In a traffic centre, this could be, for example, computing the best rerouting option for the drivers in case of an incident. Or, another example, based on the traffic conditions, the system can automatically calculate and apply dynamic speed limits.

Self-optimising also applies to the actual operation of the hardware within the traffic centre. One example would be automated management of the power consumption depending on how much demand the traffic situation and traffic management requirements put on the system.

The self-management and self-optimising functions have to be supported by a self-learning capability allowing the system to “learn” how to react based on historical data.

Self-healing is a straightforward concept: the system can automatically heal itself and continue normal operation when one or more components fail. Of course, this applies only to a certain extent and it is expected that major failures will still cause the system to stop. The self-healing function has to be accompanied by a self-diagnostic capability allowing automated detection of the errors and failing components.

The fourth proposed function is self-configuration. It means that a system is able to adapt automatically its operations whenever there is a hardware change or upgrade. For example, if new sensors are connected, the system should detect them, use their data, and expand its services taking advantage of the new available information.

11.2 Selected functions of the Traffic Management Centre

Based on the research and activities done by experts involved in EU EIP, as well as the feedback received from the stakeholders, the following functions of the TMC were selected as the most relevant for automation of operations:

- Information on unplanned events (incident/obstacles information)
- Information on planned events (roadworks information)
- Traffic time information
- Queue protection
- Line control/traffic detour
- Stationary vehicle detection
- Variable speed limits
- Dynamic Lane Management
- Temporary Hard Shoulder Running
- Ramp Management
- Weather (actual and predictions) information
- Design of traffic management plans
- Calibration of traffic management equipment/systems
- Cross-border traffic management
- Wrong way driver information

In many European countries traffic centres are faced with multiple challenges in their daily operations. As the tasks increase and become more complex, there is a demand for more operators. However, in most cases there are budget constraints, and it is not possible to hire additional human resource. In this situation, the increased automation of the operations with self-management and self-optimising functions can lead to reduced work and a more efficient provision of services.

Another challenge in traffic centres is to react and adapt to malfunctions. In this case automated systems with self-diagnostic and self-healing properties can significantly contribute to faster reaction times and minimise the downtime of operations.

A third challenge relates to data collection. A basic operation for traffic centres is to collect traffic data and to provide traffic information to users. Often there are many sources of traffic data which need to be updated frequently. Also, the information provided to road users needs to be as accurate and as timely as possible. Introducing automated and autonomic functions for data collection/update and for traffic information provision reduces the effort required by human operators and increases the efficiency of the operations as a whole.

A fourth challenge relates to geographic expansion. Often, traffic centres need to expand their geographic coverage and/or extend their systems by adding more components: sensors, displays, consoles etc. New systems and components should be put into operation fast and integrated with existing systems. This can be easily done if components are automated with plug-and-play and a self-configuration functionality which also ensures better data integration between the systems.

A fifth challenge relates to infrastructure maintenance. Maintenance of the road infrastructure is the core responsibility of road operators. In order to be achieved efficiently, it is highly important to have a good planning of roadworks. Using automated tools for this is easier and more efficient than manual planning by the operators.

11.3 Automation scales

The following scales of automation for traffic management centre operations are foreseen from the system point of view:

- Automated module (as precursor of autonomic module) – A0
- Autonomic hardware modules – A1
- Autonomic software modules – A2
- Autonomic subsystem – A3
- Autonomic system – A4

When analysing the automation from centre operator point of view, the scales with the operator versus system roles and responsibilities could be listed as follows (Kulmala, 2017[75]):

0. Operator makes all decisions utilising system output and displays
1. Operator decides, but system provides recommendations (e.g. current weather controlled variable speed limits)
2. System makes decisions on actions, but operator always has a time window to interfere. In case of no decision-making capability, the system notifies the operator and just does not make decisions
3. System makes decisions, but in case it has no decision-making capability, the decision is left to the user made aware by the system of the dilemma
4. System is capable of making decisions in all situations, but the operator may take over if there is a special need
5. System is capable of and is trusted to make decisions in all situations. No operator involvement nor presence is needed

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[75] *Kulmala, Risto (2017). Automation level – impact of operator involvement?* Presentation given at EU EIP 4.2 Consortium Meeting, London, September 21st, 2017

The scales from centre operator point of view are defined considering a gradual increase of the automation capabilities in sequential order of their numbering. Therefore, level 0 assumes no automation of systems, so the decision is left entirely to the operator.

Moving forward, in level 2, the systems always allow a time window to interfere, and it is not capable to react in all situations. In other words, it is expected that there are situations unknown to the system and thus it no longer has decision-making capability. Level 3 is similar with level 2, the difference being that in level 3 the automation is higher and as such it is not necessary to provide a time window for the operator to interfere.

Level 5 assumes the highest degree of automation when the system knows how to react on its own in all possible situation.

11.4 Scenarios for increasing efficiency of traffic management centre operations based on automated and autonomic solutions

Autonomic applications can be considered as multi-layered, with integration of the layers building automated components into an overlapping autonomic system. In this section, the following scenarios for introducing automation are proposed and the expected benefits for traffic management centre operations are discussed:

- Minimum system update: automation of only hardware components/modules.
  This scenario could include the implementation of system with a single automated function, for example an automatic number plate recognition (ANPR) system with self-diagnosis capability that alerts the traffic management operator if a drop in capture rate performance is detected, or the implementation of self-configuring / "plug and play" system components reducing the need for local set-up and configuration.
- Intermediate system update: automation of hardware components/modules and automated data collection/information provision for some operations.
  In this scenario automated components/modules are combined, these could include:
  - Automated fault management and maintenance systems to collate diagnosis and fault information from field equipment, determine and propose optimised repair schedules.
  - Roadworks scheduling and booking software to avoid resource conflicts and forecast completion.
  - Traffic management measures, such as coordinated traffic responsive ramp metering, hard shoulder running and variable speed limit algorithms.
- Significant system update: automation of hardware components/modules, automated data collection/information provision for some operations and operations with self-management characteristics – actions are calculated and proposed to the operator.
  This scenario reflects a more complex, large-scale integrated traffic control system where the modules / sub-systems of traffic detection (e.g. inductive loops, ANPR), management (e.g. variable speed limit, ramp metering) and information (e.g. VMS, traveller apps) are connected and actions can be proposed by the system based on the current and / or predicted conditions. For example, in the event of an incident an automated alert from a queue protection system is signalled in the traffic management centre. The system can propose the lane closure pattern, supporting information messages on VMS in the vicinity, and appropriate reduced mandatory speed limits. These proposals are then accepted or rejected by the operator.

Looking further into the future, it could be possible for the traffic management centre operator to define the desired outcome based for example on a vehicle emissions target or throughput, and the system would analyse and implement the measures required to achieve the target. With increasing self-management, the system would be able to carry out and monitor the execution of the plans and learn and adapt from experience.

11.5 Examples of Existing TMC automation

11.5.1 Traffic Control Centre (TCC) Hessen

The traffic situation and travel time are calculated automatically with the traffic model DIVA (dynamic integrated traffic situation analysis). The travel and loss times, which are generated based on the measured traffic volumes, are the basis for e.g. the dynamic signs and traffic messages, which are published online via the traffic service. These dynamic signs are implemented on several locations in the Hessian road network.

The slot management system automatically checks if the transport system can handle a roadwork and determines suitable time slots for projected works on motorways.

As shown in Figure 11.1, possible timeslots for any planned short-term road work are calculated as result of the evaluation in terms of their effects on traffic. After selecting the road section and the number of blocked lanes, the system calculates possible timeslots based on traffic data, expert knowledge and rules. These timeslots are presented in green. Timeslots which are marked in red cannot be selected due to the risk of congestion.

Straßen-Nr.: A3

Knotenpunkt von: Obertshausen

Knotenpunkt bis: Hanau

Sperrung: von links

gesperrte Fahrstreifen: 1

☑ Seitenstreifen mitbenutzen

☐ Zeitvorgaben übergehen

Grund: Bitte wählen

Datum	Richtung: Würzburg	Richtung: Köln
Fr, 15.06.2012	🟩 bis 12:30 🟥 12:30 - 18:30 Staugefahr 🟩 ab 18:30	🟩 bis 06:00 🟥 06:00 - 09:00 NM 017.2-2012-3, Staugefahr 🟩 09:00 - 12:00 🟥 12:00 - 19:00 NM 017.2-2012-3 🟩 ab 19:00
Sa, 16.06.2012	🟩 ganztägig	🟩 ganztägig
So, 17.06.2012	🟩 ganztägig	🟩 ganztägig
Mo, 18.06.2012	🟩 bis 15:30 🟥 15:30 - 18:30 Staugefahr 🟩 ab 18:30	🟩 bis 05:45 🟥 05:45 - 09:15 NM 017.2-2012-3, Staugefahr 🟩 09:15 - 14:30 🟥 14:30 - 19:00 NM 017.2-2012-3 🟩 ab 19:00
Di, 19.06.2012	🟩 bis 15:00 🟥 15:00 - 18:45 Staugefahr 🟩 ab 18:45	🟩 bis 06:00 🟥 06:00 - 09:15 NM 017.2-2012-3, Staugefahr 🟩 09:15 - 14:00 🟥 14:00 - 19:00 NM 017.2-2012-3 🟩 ab 19:00
Mi, 20.06.2012	🟩 bis 14:45 🟥 14:45 - 18:45 Staugefahr 🟩 ab 18:45	🟩 bis 06:00 🟥 06:00 - 09:15 NM 017.2-2012-3, Staugefahr 🟩 09:15 - 14:00 🟥 14:00 - 19:15 NM 017.2-2012-3 🟩 ab 19:15
Do, 21.06.2012	🟩 bis 14:45 🟥 14:45 - 19:00 Staugefahr 🟩 ab 19:00	🟩 bis 06:00 🟥 06:00 - 09:15 NM 017.2-2012-3, Staugefahr 🟩 09:15 - 14:00 🟥 14:00 - 19:00 NM 017.2-2012-3 🟩 ab 19:00

Figure 11.1: Slot management system (source: Hessen Mobil)

11.5.2 Spanish Traffic Management Centres

This automation of traffic time information provision is based on theoretical calculations given by predefined rules inserted in the system. In this particular case, the automatic system checks whether the time criteria are met and is responsible for sending a message automatically to the VMS assigned for the signalling.

Some examples of calculations at the Southeast Traffic Management Centre of Directorate-General for Traffic (DGT) in Spain are explained in detail in Figure 11. for two sections located in A-7 and AP-7 (one for each direction).

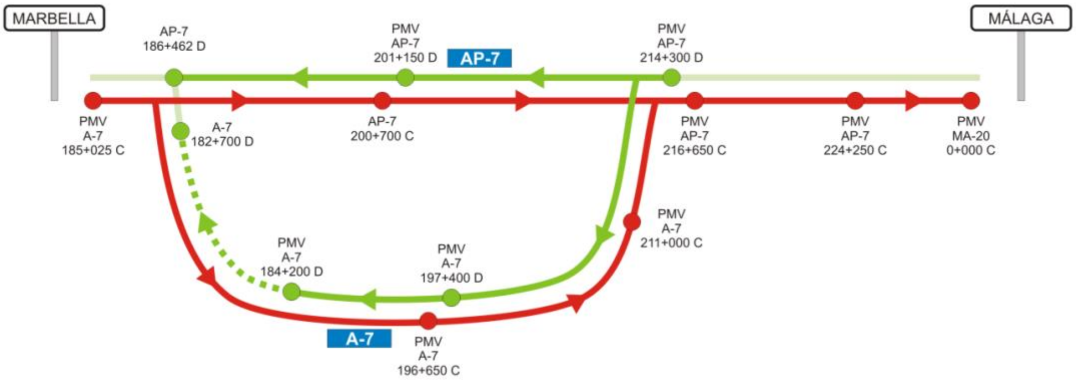

Figure 11.2: Travel times signalling between Málaga and Marbella (source: DGT, Southeast TMC)

This DGT Southwest TMC manages the “Automatic deployment of signalling plans” with a specific tool. The feature shows all the VMSs that can be modified and asks for a priority to signalling as default, in case there is no signalisation. There are three kinds of priorities: A, B and C. The behaviour of the tool will depend on the priority used for the signalisation. In case there is more than one priority, only the prime one will be considered. The interface of the application allows making changes on the configuration, defining priorities and specific messages for each case.

11.5.3 T-LOIK in Finland

In Finland, many traffic management actions are currently semi-automatic in the sense that the systems automatically deduce the appropriate traffic management actions, e.g. the change of the dynamic speed limit based on the development and short-term forecasts of road weather related indicators. The actual action, in this case, the change of the speed limit will be executed by the traffic centre operator by accepting the system proposal or by carrying out some other action. Some Variable Speed Limit (VSL) sections work automatically, without acceptance of the TMC operators. These VSL sections are typically controlled by data such as a predefined time schedule.

Figure 11.3: Weather controlled Variable Speed limits (source: FTIA)

In Finland, automated data acquisition is routinely carried out by hundreds of traffic monitoring stations, road weather monitoring stations, and CCTV cameras. The data is transmitted by the stations at intervals of 1-20 minutes. In addition, AID (Automated Incident Detection) is in operation in selected critical spots and sections, mainly tunnels. The diagnostics of roadside ITS has also been implemented so that whenever the roadside station or the central system polling the roadside station observes a malfunction, this is automatically reported to the traffic centre operator and/or the contractor responsible for the operation and maintenance of that particular station.

A key aspect of data acquisition is to obtain data on incidents on the network. One important source for this data is the emergency centre organisation managing the PSAPs (Public Safety Answering Points). In Finland, the emergency centre's accident and incident data base sends automatic messages to the traffic centres concerning the location, type, severity and other features of the accident or other incident in question.

In Finland, many tunnel sections are equipped with wrong way driver detectors. A detection is based on the data by loops in the ramps before the tunnel or by AID systems in the tunnel area. The control system gives an indication of a wrong way driver in the TMC, and the operator can execute appropriated traffic control actions by using the proposed selection. When the alarm is indicated by the AID system, the action is executed automatically without acceptance of the TMC operator. The actions might be warnings on VMS and speed limit reductions.

In Finland, some tunnels have a queue protection system based on automated queue detection. The traffic control actions perform as a vehicle access control system closing the entrance to the tunnel with either traffic signals or lane control signals, and the system works independently without surveillance of the TMC operator.

A few tunnels are equipped with the slowly moving vehicle detection and sun glare warning systems. The slowly moving vehicles are detected by the inductive loops before the tunnel and the risk of glare is measured with the sensor at the end of the tunnel (glare is most critical inside the tunnel, just before the end of the tunnel). The system provides warnings of these situations to the drivers via VMS.

Travel time information is shown to the road users by the VMS and the data is accessible to service providers via an open data interface. The information is based on the data from a private service provider, and it has been aggregated for use on the appropriate road segments. The whole process works automatically.

11.5.4 Traffic Scotland Systems

The queue management system is closely aligned with the rules-based response architecture and is a key tool in the management of the Traffic Scotland road network. Within the Incident Management System (IMS) a queue is handled as a type of Incident, the details of the Incident are updated as the queue develops. The system automatically detects queues, modifying their details in order to track them as they develop, and eventually clears the queue when it dissipates. Queues are dynamic in that they can diverge and merge, expand and contract. Updating, tracking and responding to queues forms the process of Queue Management.

A key component part of successful Queue Management is the automatic use of Motorway Signalling Units (MSUs), Hazard Flashers, and VMSs as part of the Local Algorithmic Response (or LAR) Queue response to Incidents (example screenshot in Figure 11.4 below). In addition, VMSs can be set as required by the Wide Area Algorithmic Response (or WAAR) Queue response to the Queue Incident. The LAR provides supplementary 'Local' information to drivers within the queue, such as "Congestion after J11" and "Slow for x Miles", to minimise potential driver frustration.

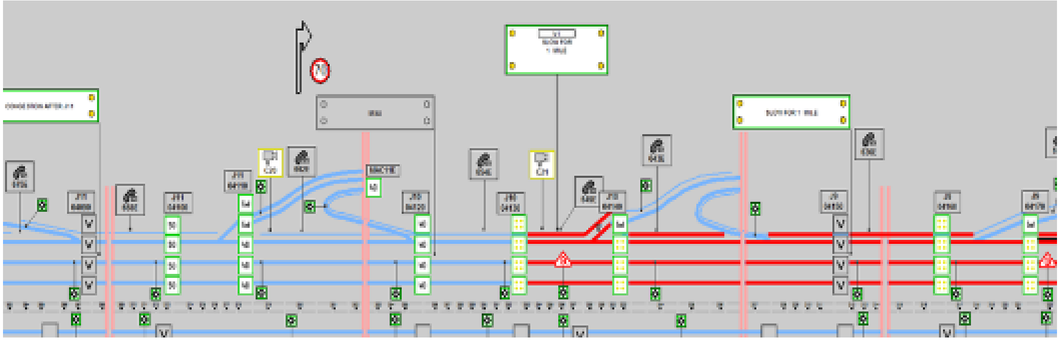

Figure 11.4: Example of Queue Management and LAR (source: Transport Scotland, IMS)

11.5.5 Netherlands traffic management centres

The que protection system utilises flashing lights and variable speed limit signs to alert drivers for the end of a queue and recurrent congestion. The function is automated and based on field data, is initiated automatically based on an assessment algorithm, requiring no intervention by an operator. It is also used to warn for lane closures and incidents.
The truck height warning system comprises a vehicle-height measurement sensor, a camera, and roadside dynamic route information panels (DRIP, Dutch abbreviation for VMS) as shown in Figure 11.. Some systems are also capable of displaying a photograph. If the height measurement sensor is triggered by a vehicle, it sends a signal to the camera, which then takes a picture of the vehicle. The photo is sent to the DRIP and is then displayed on the sign's screen, together with a request to take the next exit.

Figure 11.5: Example of (Truck) height warning (source: RWS)

11.6 Implementation roadmap

Based on our research, we did not identify any other studies dealing with the increased automation and autonomic functionality of road operator ITS. However, it became obvious that the emergence of automated vehicles and C-ITS will be a major incentive for automation of TMC operations. Hence, the multiple existing roadmaps for automated driving development were taken into account and especially the most recent one from ERTRAC (2019)[76]. In addition, we took into account the results of a survey performed by Activity 4.3 of EU EIP, which shows that there is a 5-10 year cycle of upgrading existing ITS infrastructure.

As a result, we set the target for the roadmap to 2030 with three milestones in 2021, 2024 and 2027. We consider 2030 to be the target point of a 10-year period when, pressured by

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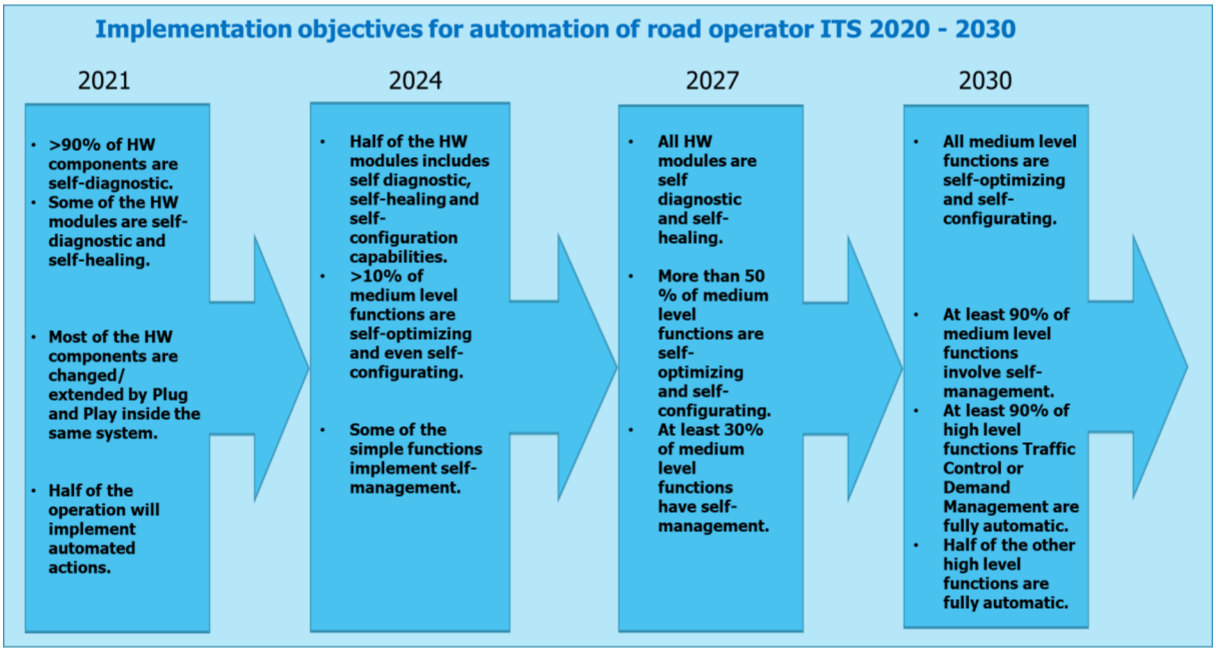
[76] https://www.ertrac.org/uploads/documentsearch/id57/ERTRAC-CAD-Roadmap-2019.pdf

developments in automated vehicles and C-ITS, road operators need to upgrade their systems while at the same time the market penetration of automated and especially connected vehicles will reach considerable levels. And, by that time, we believe most European road operators also recognise the benefits of increased automation and will consider implementing autonomic functionalities as part of the upgrade. Finally, as the penetration of automated vehicles is expected to rapidly increase towards the end of the period, we believe another upgrade of TMCs can be done by 2030 with an even stronger focus on fully autonomic behaviour.

The foreseen implementation objectives are presented in Figure 11..

The first period in the roadmap was until 2021. In this timeframe it was expected that mostly the hardware (HW) level will increase its automation. As such all TMCs would have had complex asset management systems for all components. It was estimated that more than 90% of hardware components sold on the market would be capable of monitoring their status and generating alarms. Also, most of the hardware components were expected to be plug-and-play. Moreover, it was predicted that existing traffic management basic operations (e.g. variable traffic control, traffic and weather monitoring, etc.) would be enhanced and new ones would be introduced towards having at least half of the operations automated, with or without operator intervention for validation.



2021

- >90% of HW components are self-diagnostic.
- Some of the HW modules are self-diagnostic and self-healing.
- Most of the HW components are changed/ extended by Plug and Play inside the same system.
- Half of the operation will implement automated actions.

2024

- Half of the HW modules includes self diagnostic, self-healing and self-configuration capabilities.
- >10% of medium level functions are self-optimizing and even self-configurating.
- Some of the simple functions implement self-management.

2027

- All HW modules are self diagnostic and self-healing.
- More than 50 % of medium level functions are self-optimizing and self-configurating.
- At least 30% of medium level functions have self-management.

2030

- All medium level functions are self-optimizing and self-configurating.
- At least 90% of medium level functions involve self-management.
- At least 90% of high level functions Traffic Control or Demand Management are fully automatic.
- Half of the other high level functions are fully automatic.

Figure 11.6: Implementation objectives for automation of road operator ITS

From 2021 to 2024, the automation focus should start shifting from hardware to system functions (e.g. queue protection, dynamic lane management, weather information, etc.). In terms of hardware, more than half of the modules would be capable of self-diagnostic, self-healing and self-configuration without human intervention in at least in 95% of cases. With reference to the functional architecture introduced in EU EIP deliverables[77], by 2024 more than 10% of the medium level functions would be capable of self-optimising and self-configuration. Some of the simple functions should have self-management properties, even without operator intervention.

Starting from 2024 and until 2027 all hardware modules installed would be capable of self-diagnostic and self-healing at least in 95% of cases without human intervention. The proportion of medium level functions capable of self-optimising and self-configuration would increase to

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[77] Deliverables can be found at: https://www.its-platform.eu/achievement/how-to-automate-road-operators-own-its

more than 50%. Also at least 30% of the medium level functions would be capable of self-management.

Starting from 2027 to 2030, we could expect that all medium level functions are capable of self-optimising and self-configuration. In addition, almost all medium level functions include self-management capability, at least in terms of management of the system itself. As mentioned before, the self-management autonomic function includes three sub-functions of management of the system itself, management of the traffic, and management of operational activities. It is likely that the application of self-management will follow that order. However, in some medium level operational functions, the management of traffic or even management of operational activities could be realised before the management of the system itself. This has already been the case e.g., for remote controlled traffic signal systems or some tunnel management systems. During the period we could also expect at least 90% of the systems to have full autonomic properties in two high level autonomic functions of the ITS, either Traffic Control or Demand Management, and being able to provide services without operator intervention in almost all situations.

The conclusions of the road map to the actual actions proposed to be carried out by the road operators are summarised in Figure 11..

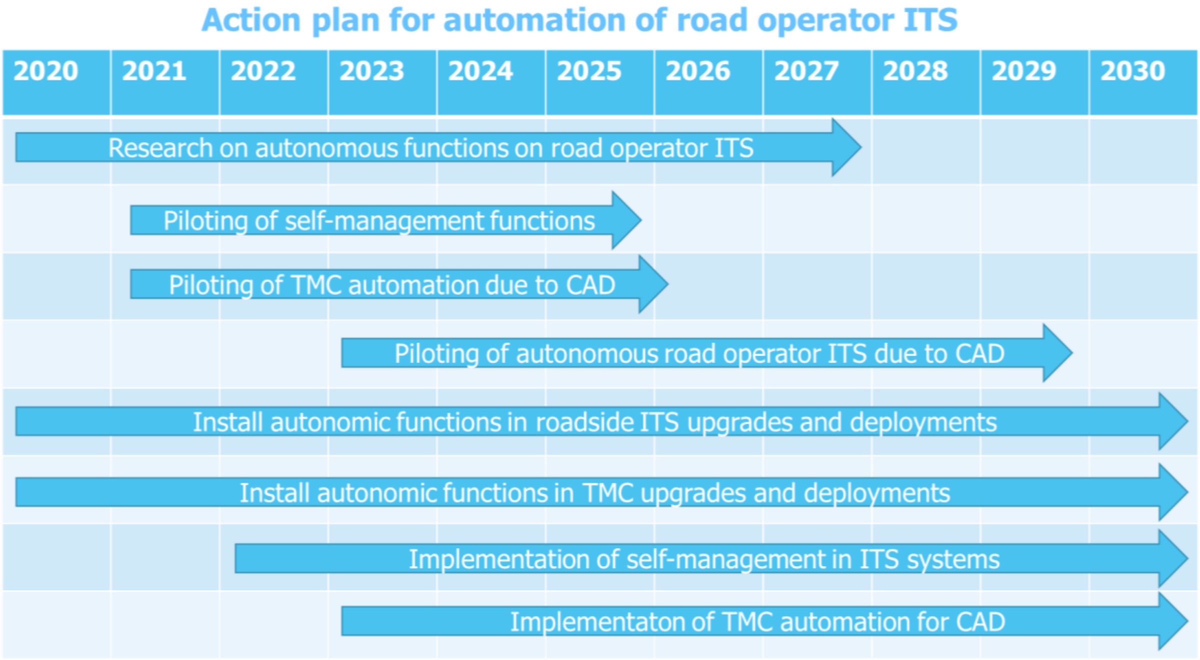

Figure 11.7: Proposed action plan for automation of road operator ITS

11.7 Conclusion

The work on automation of TMCs operations was carried out in EU EIP using input from the participating partners who identified and described the functions and applications which are already installed in their respective countries: Finland, Germany (Hessen), UK (Scotland), Spain, The Netherlands.

The description of the systems in the EU EIP deliverables included an expert judgement of the participating partners regarding the scales of automation for each implemented function. Although there is a large variation of the values among the different systems, functions with an overall low level of automation and, on the other hand, ones with an overall high level, can be identified. For example, traffic time information scored at least 4 on the scale from the operator point of view in all implementations. In contrast, hard shoulder running scored at most 3 on the same scale, even as low as 0 in one implementation.

All systems studied by EU EIP experts have automated operations for one or more of the TMC functions that are considered by the authors as the most relevant to benefit from automation. In some cases, other functions specific to the local needs (for example Truck Hight Warning or Network Control Systems) were also automated. This strengthens the general conclusion that automation is needed and brings benefits for TMCs. However, there should be a balance between automation and the involvement of human operators. In this respect, the operators should always be capable to and have the means to intervene whenever the system requires input, or when it becomes obvious that the system decision leads to a safety risk.

The EU EIP partners also proposed a roadmap up to 2030 for the implementation of automation in the current and future TMCs. The main conclusion from the roadmap is that the deployments should be continuous with regard to the automated functions. The ones that have been proven to work in an appropriate manner with sufficient economic feasibility should be routinely installed when deploying new ITS or upgrading existing ITS both by the roadside and in traffic management centres.

12 The Future of Traffic Management

Author: Dr. Johanna Tzanidaki (ERTICO – ITS Europe)

12.1 Evolution of what is traffic management

In Europe, traffic management centres (TMCs) are responsible for monitoring and controlling the road network in their constituency so as to ensure a flow of vehicles and avoid congestion. Road lanes, traffic signs and traffic signals, driving regulations and parking regulations are some of the tools that TMCs use in order to prioritise certain vehicles and guide others to reach their destinations. It is a complex process which involves, among others, city planners, traffic engineers, civil protection authorities, traffic information providers and also users.

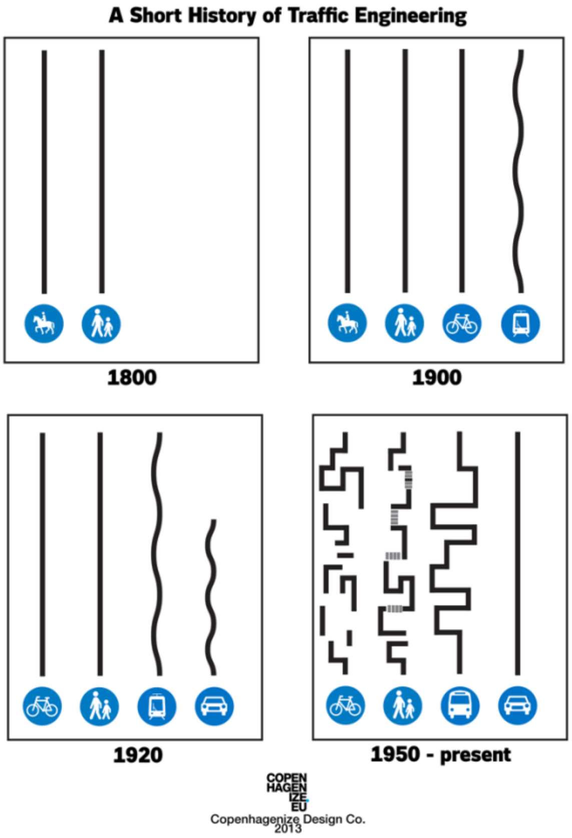

Figure 12.1: history of traffic engineering

In the iconographic of A Short History of Traffic Engineering by the Transformative Urban Mobility Initiative (TUMI)[78], the progression of prioritising different road users from the 1800's to the 1920's and 1950's is indicative of the shift of priorities that have guided traffic management practiced in urban areas. Vehicles have been prioritised since the 1950's in terms of convenience in routing and the entire focus has been vehicle- rather than human centred for almost 100 years.

In the modern process of traffic management, the TMCs are called daily and even hourly to juggle the various interests of the traffic stakeholders and road user groups and facilitate faster mobility to some but not to all. The focus of TMCs has started shifting from vehicle to human some seven years ago, with the establishment of the TM 2.0 ERTICO Innovation Platform.

The TM 2.0 ERTICO Innovation Platform was set up by traffic stakeholders who shared the belief that traffic management could be both dynamic and cooperative. The focus of work for this group of public and private organisations, who gathered under the Innovation platform was the vehicle's interaction with traffic management. Managing the flow of vehicles on the road network is now understood as necessitating the cooperation of traffic management centres, service providers and the traffic industry providing the physical and digital infrastructure (Mobile Network Operators as well as OEMs) in guiding the users[79].

In contrast to the traditional traffic management practices where traffic management centres did not have a direct collaboration with in-car data providers and OEMs, TM 2.0 makes use of real time traffic information and data (such as Floating Vehicle Data (FVD)) and the wider

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[78] https://www.transformative-mobility.org/assets/publications/A-Short-History-of-Traffic-Engineering.pdf

[79] The work of the TM 2.0 Innovation Platform can be accessed at www.tm20.org

coverage this offers with regards to real-time traffic information in order to ensure that better traffic information services can be available.

The figure below shows the data needed for the TM 2.0 concept to be operational: all data from all sources. That means that the ecosystem of traffic management, according to the TM 2.0 concept is quite wide. Wider than TMCs and vehicles alone, as was seen in the traditional traffic management operations in the previous decades.

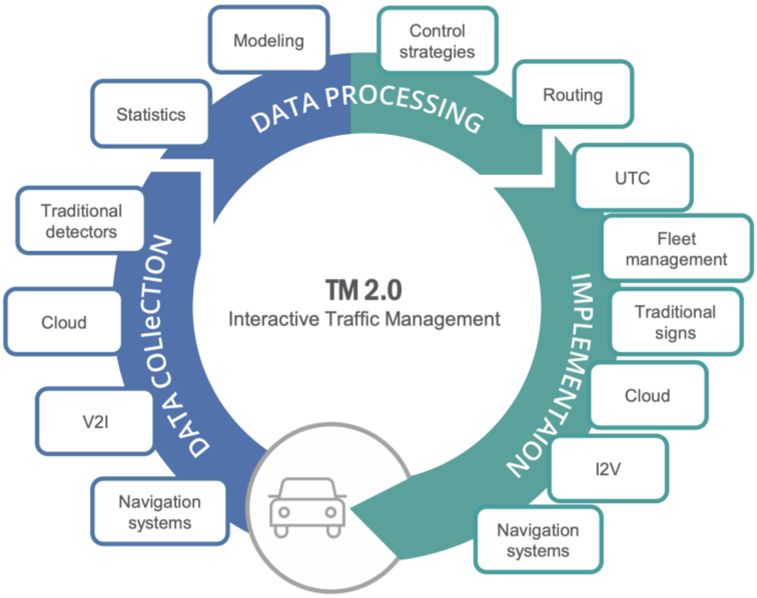
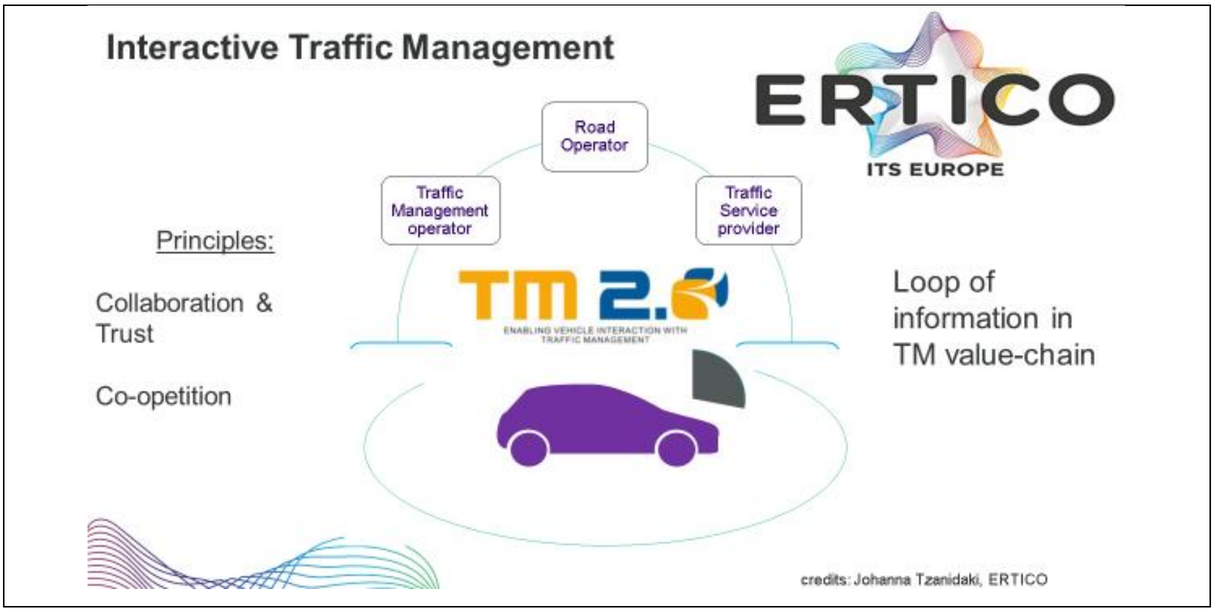


Figure 12.2: data needed for the TM 2.0 concept

Moreover, in TM 2.0, traffic stakeholders cooperate into providing a more holistic traffic management experience, which takes into account and accommodates the individual driver's needs, while at the same time it also satisfies the objectives set by the public authorities and the traffic management centres for the collective benefit of road network users.

TM 2.0 is a governance concept embraced by public authorities and the private traffic stakeholders alike and has gained great momentum in the last 6 years. The principles of TM 2.0 are Co-opetition and Trust: Co-opetition for all stakeholders that cooperate in attaining the objectives, as set by public authorities with regards to rerouting, geo-fencing and environmental targets but continue to compete on their services to their users based on quality. Trust is the basis upon which the TM 2.0 concept on interactive traffic management (TM 2.0) is operational. Stakeholders from the public and the private sector in traffic management trust and understand each other's needs and priorities. They all cooperate towards the common set objectives of alleviating traffic and attaining the common goals set by the public authorities and they trust on the agreed win-win-win among them.



Interactive Traffic Management

Principles:

Collaboration & Trust

Co-opetition

Loop of information in TM value-chain

credits: Johanna Tzanidaki, ERTICO

Figure 12.3: The concept of TM 2.0

On a road intersection, not all traffic lights can be green. Justifiably then, not all vehicles can drive through. Some of them have to wait and some will have to wait longer. We are used to the fact that coming from a secondary road onto a primary road (roads are classified according to their speed, accessibility and capacity to host driving vehicles throughout the road network), we could be waiting a bit longer. At the same time, it is also usual that during peak traffic hours (most commonly perceived to be 08.00-09.30 and 17.00-19.00, when the majority of the population goes to and back from work) vehicles will be prioritised and pedestrians will have to wait somewhat longer to cross the road.

However, what is exactly the role of traffic management? Is the role of traffic management to prioritise on vehicles instead of pedestrians, or is it simply an act of exercising control and guidance to reach one's destination without interfering with such city dynamics? The next part of the chapter will attempt to give a modern perspective into answering this question.

12.2 Role of traffic management in modern transport and mobility

For the past ten years, the TomTom Traffic Index has been providing detailed insights on traffic congestion levels in over 400 cities around the world. The report ranks cities from the most to the least congested and it is based on the analysis of historic and real time traffic information, collected by among other types of data, also Floating Car Data (FCD). Calculating the baseline per city, the TomTom Traffic Index ranks cities comparing the free-flow travel times of all vehicles on the entire road network in the cities. Included in its index is the extra time a driver will spend in traffic during rush hour in the same cities on the same date and time. By calculating all hours of each day, analysis can see congestion levels at any time in any city.

Montreal traffic 2020

BEST TIME TO AVOID

What day of the week had the worst rush hour?

Wednesday, 4 PM - 5 PM

Travelling after 5 PM on Wednesday could save you up to 2 hours per year (for a 30-minute commute).

WEEKLY TRAFFIC CONGESTION BY TIME OF DAY

https://www.tomtom.com/en_gb/traff

Information such as the one on the table seen on the right is useful to both the driver and the public authorities of the city in question, in this case Montreal (CAN). The driver using the road network is aware of the best times to travel while the TMC is informed on what to expect and which bottlenecks it should be working on solving with regards to the traffic congestion on the road network.

The role of TMCs is indeed to ease traffic congestion and facilitate the better flow of traffic in the road network. Nonetheless, cities and their decision-makers have changed their priorities in the past years from prioritising the flow of vehicles to prioritising the flow of pedestrians and bicycles by means of green traffic lights during peak hours. A good example is the city of Amsterdam, which in 2013 announced in its Action Plan for Mobility the creation of separate priority networks for bikes, parallel to priority networks for public transport and for motor vehicles[80]. Not prioritising on 'speed' anymore, Amsterdam decided to prioritise different modes of transport on different streets. Restricting or prohibiting vehicles in certain parts of the city (geo-fencing), can help prioritise on certain user groups in the road network and ensure at the same time the safety of all. TMCs are more and more opting for this new role in Traffic Management, one that regulates the flow of mobility modes and not that which ensures the flow of vehicles in the road network.

Making a division between traffic and motorised traffic forms part of the latest developments in traffic management. TMCs are now actively promoting non-motorised forms of mobility as part of a healthier and more environmentally friendly urban lifestyle. The city of Copenhagen's (DK) priority on mobility, aims at a target of 75% of all mobility to be on foot, by bike or by public transport (as stated in the CPH 2025 Climate Plan[82]).

Mobility in Copenhagen

….A higher proportion of cyclists, public transport users and pedestrians will leave more space on the roads for commercial traffic and people for whom a car is a necessity of day-to-day life.….

Better flow

Maintaining good traffic flow in the city involves both optimising the traffic system and aligning it with users' expectations. The City of Copenhagen is working closely with traffic management experts on this, and has adopted service targets for cyclists, pedestrians, buses and cars. The targets will help make it clear which target group is prioritised on which routes.

'Good, Better, Best. The City of Copenhagen's Bicycle Strategy 2011-2025' (2012)[81]

Traffic Management is nowadays part of urban planning and climate strategies need to be integrated into the entire traffic management operations. The city of Copenhagen is working towards enhancing the efficiency and sustainability of its transport and modernises its definition of traffic management into the balancing of the interests and needs of the users of the mobility network. That novel way of thinking in traffic management attempts to see the entire mobility system in a holistic manner as it also attempts to balance the flow of all mobility modes within it: motorised traffic, bicycles, pedestrians.

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[80] https://www.amsterdam.nl/en/policy/policy-traffic/policy-pedestrians/

[81] https://kk.sites.itera.dk/apps/kk_pub2/index.asp?mode=detalje&id=823

[82] https://ecf.com/sites/ecf.com/files/Tin.E_Cycling_Data_for_Active_Traffic_Management_in_CPH.pdf

Transport for London (TfL) has created a multi-criteria optimisation scheme for London's Traffic Management, which was/is not only based on the conventional 'stops and delays' optimisation of traffic through the road network traffic lights, but it also attempts to optimise traffic, including Public Transport, cyclists[83] and pedestrians[84] on, for example, emissions-based status[85] of the network.

12.3 Stakeholders and Key players in modern traffic management

Who the stakeholders are in modern Traffic management and what their role is in traffic management operations, very much depends on the priorities driving the actions on the public authorities and their TMCs. If a city (or a country) has taken the political decision to prioritise on motorised traffic rather than climate friendly modes, the traffic management stakeholders and key players are defined from within the road-based mobility ecosystem. If a city prioritises on active modes of transport (cycling, walking etc.), then traffic management stakeholders are to be identified amongst a number of traffic management players, including the traffic service providers as well as stakeholders from the cycling industry and walking, enabling *infrastructure and relevant traffic information (walking paths and routing options).*

The Urban Mobility Index[86] of HERE (see figure here on the right), allows drivers of motorised mobility in Copenhagen to use an interactive map (see figure on the right and answer for themselves the questions of Am I going to get delayed in traffic if I take the car today? When should I leave, if I want to avoid a jam? Based on the analysis of vast amounts of data collected by the company, patterns of city congestion and how these change during the different hours in the week allow citizens to make informed decisions.

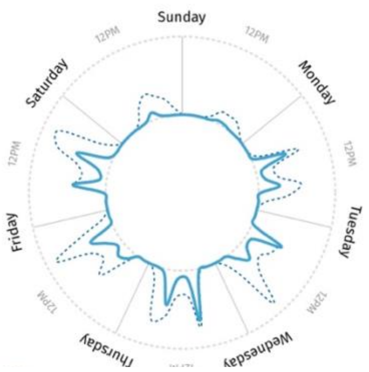

Figure 12.4: Urban Mobility Index (HERE)

The stakeholders in Copenhagen however are not considered to be only the drivers of motorised mobility. The city's innovative approach to traffic management has led it to participate in the SOCRATES 2.0 EU funded project (2018-2021), which has used Copenhagen as one of its four pilots. Implementing the TM 2.0 Interactive Traffic Management concept, which will be discussed in the next part of this chapter, the project has attributed co-creation powers to the stakeholder group of bicycle users by integrating the management of bicycle flows into that of motorised traffic management.

The city's plans for active traffic management, as set in 2019, dictated that data and active traffic management should also be for bicycle traffic[87]. Collecting data from bicycle traffic is helping the city optimise the entire traffic network.

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[83] https://content.tfl.gov.uk/PCaTS-Note-2-Overview-Presentation.pdf

[84] http://www.jctconsultancy.co.uk/Symposium/Symposium2018/PapersForDownload/Saving%20Time%20for%20Bus%20Passengers,%20Pedestrians%20and%20Cyclists%20in%20London%20-%20Heidi%20Smart%20and%20Wissem%20Lakache%20-%20TfL.pdf

[85] http://www.jctconsultancy.co.uk/Symposium/Symposium2018/PapersForDownload/Healthy%20Streets%20in%20London%20-%20using%20our%20signals%20creatively%20to%20make%20the%20capital%20healthier%20-%20Helen%20Cansick%20and%20Joe%20Birdseye%20-%20TfL.pdf

[86] http://urbanmobilityindex.here.com/city/copenhagen/

[87] https://ecf.com/sites/ecf.com/files/Tin.E_Cycling_Data_for_Active_Traffic_Management_in_CPH.pdf

The stakeholders in modern traffic management are all those players that have a right to use the mobility network and they have stakes in its optimal operation and a responsibility to keep the network flexible and flowing. Traffic Management operators, Road Operators and Service Providers, including the traffic industry and OEMs who act as service providers (and not only as users) as well as drivers themselves are all considered as important stakeholders in managing traffic. The TM 2.0 concept requires traffic management stakeholders to trust each other and cooperate for the attainment of the common goals, as these are set by the public authorities. The principle of cooperation among competitors is termed as co-opetition and road authorities are seen as the ultimate orchestrators of the goals that should be reached by all stakeholders involved by following a win-win-win approach. The public authorities are guardians of the societal values and targets aiming for the common good.

Returning to the first statement of this section, the traffic management stakeholders is a group that expands of decreases according to the priorities set by the public authorities with regard to the mobility envisioned by the decision makers. As the latter become more and more keen to identify traffic priorities that impact more than one groups and more than one mobility modes, the groups of stakeholders become more diverse and wider.

12.4 Traffic management and Automation

The gradual presence of automated vehicles (of SAE level 3 and above) on the road network is indisputable within the mobility community. What is still being debated is the span of years during which our traffic will consist of legacy and automated vehicles. Some argue that we should expect this to be of 30 years duration while others argue that it will be 15. While the debate still goes on, the traffic management community is closely following the work being conducted in platforms such as the European Truck Platooning Platform (ETPC) and projects such as ENSEMBLE, that look into truck platooning and automation based on algorithms and technology that allows heavy vehicle trucks 'locked' in a platoon on certain stretches of highways. The community is also monitoring closely how the automation of public transport is being addressed in projects such as the EU-funded SHOW project and how public transport can be a first use case for mass automation on our urban roads. The sooner the use case for mass automation is able to demonstrate that there are benefits for all users and stakeholders involved, the more positive the public engagement with automation in transport will be.

At the same time, current traffic management procedures are being impacted by automation in road transport. Automated vehicles, expected to be part of mixed traffic for the years to come, should be integrated into the transport system without endangering the set practices of prioritisation, road safety and traffic stakeholder cooperation. It is certainly true that automated vehicles can function on their own, which is indicative of their ability to drive themselves (autonomously even) from A to B without the need to interact with traffic management tools, other than traffic lights and speed limits of course. However, this can only happen in protected environments of pilot sites and test beds. In real life, as in real traffic, automated vehicles will drive next to legacy ones and this is why the physical infrastructure is undergoing a much needed transformation, or shall we say,' translation' into its digital twin so as to be understood and 'read' by both automated and legacy vehicle systems.

The EC has recognised the challenge of transitioning from a classic physical traffic management system to one that can also serve automated vehicles and offers a specific funding line for the vehicle integration into the CCAM (Connected Cooperative Automated Mobility) system via its Horizon Europe CCAM Calls for the years to come. In the words of the TM 2.0 Innovation Platform: "Road automation is expected to enable the provision of more reliable, effective and efficient Traffic Management services, which will increase road safety and efficiency and enhance environmental protection. High quality, detailed data of the current status of the road network and of the whole transport system should be always available, covering the whole road network. The traffic environment should be harmonised, while data privacy and security should be also safeguarded. New communication means with the automated vehicles should be conceptualised and designed, replacing the traditional communication means with human drivers, and this may require changes in the physical infrastructure"[88].

In preparation to host mixed and (later) fully automated traffic flows, the transport community has been working on identifying Infrastructure Support for Automated Driving (ISAD) levels that will be able to indicate to users and vehicle systems if and at what level certain parts of infrastructure can host and support automated vehicles. At the same time, managing and regulating the circulation of automated vehicles becomes the responsibility of both the public authorities via their traffic management practices and also of OEMs, as the integration and communication of automated vehicles and their surroundings (legacy vehicles and infrastructure included) becomes instrumental of the safety and efficiency of transport and mobility.

Following the TM 2.0 principle of orchestration in traffic management, it is the public authority via its traffic management that is called to enact the framework (plans and procedures) within which automated vehicles can (or should) follow the routing advice originating from the traffic management centre. On the other hand, high levels of communication between the automated vehicle and the infrastructure (via 5G and beyond but also via ITS G5) or the automated vehicle and the other vehicles and with the rest of the road users such as pedestrians, cyclists and others are currently under development so that the holistic approach in traffic management is ensured and safety is the least impacted. The 'orchestra' of mobility, comprises of all kinds of modes that together, and if orchestrated well, can produce a harmony (rather than chaos).

12.5 Traffic and Mobility Management

Safety is the first and most important priority in traffic management. The EU Strategic Transport Research and Innovation Agenda (STRIA) Roadmap for 2050[89] has recognised safety to be the game changer in the evolution of traffic management[90].

Conducted in 2016, the EU commissioned STRIA RoadMap for 2050 has concluded:

> "Traditional traffic management, which today applies more or less restrictive measures (i.e. access control) to ensure mainly security, safety and efficiency, will evolve to a very flexible "slot management" type toolbox. Whilst today's NTM (Network Mobility Management) efforts can be inefficient in trying to improve traffic flow management, the focus of NTM can turn to unprecedented new arbitration and incentive models, enabling entirely new traffic management strategies. The coordinated and collaborative intelligence can decide for each individual journey to be served by the assignment of a bespoke time and network slot on its journey from A to B."[91]

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[88] https://tm20.org/wp-content/uploads/2017/06/TM2.0-TF6_Road-Automation-phase-I_Final-report-full.pdf

[89] STRIA Roadmap Network and Traffic Management Systems Nov 2016, Expert Group Rapporteurs Steve Kearns, Hanfried Albrecht, Andrea D'Ariano, Gino Franco, Johanna Tzanidaki (https://trimis.ec.europa.eu/sites/default/files/stria_roadmap_-_network_and_traffic_management_systems_0.pdf)

[90] STRIA Roadmap Network and Traffic Management Systems Nov 2016, Expert Group Rapporteurs Steve Kearns, Hanfried Albrecht, Andrea D'Ariano, Gino Franco, Johanna Tzanidaki p.31 (https://trimis.ec.europa.eu/sites/default/files/stria_roadmap_-_network_and_traffic_management_systems_0.pdf)

[91] STRIA Roadmap Network and Traffic Management Systems Nov 2016, p.3 Expert Group Rapporteurs Steve Kearns, Hanfried Albrecht, Andrea D'Ariano, Gino Franco, Johanna Tzanidaki

The relation of services under Mobility as a Service (MaaS) schemes and traffic management has been the subject of numerous sessions held at the ITS Congresses (European and World) since 2017. The topic has also been the scope of work of two Task Forces under the TM 2.0 Platform[92]. The results of the work of the TM 2.0 Task Forces that have been analysing the topic and the conclusions reached during the dialogue within the traffic management community is that multimodality is key in reducing traffic congestion, the latter being the subject of traffic management operations.

It is becoming more and more obvious to the traffic management stakeholders that a road network cannot achieve load balance unless the individual users of the transport network are routed (or rerouted) to less congested routes in real time and according to the needs and priorities of the network as these are set by the public authorities in cooperation with the private traffic industry stakeholders. In simpler words, the road network does not operate in a silo. It affects and is affected by the choices or the transport network users, either they decide to use their vehicle or public transport or other modes of transport. The user who wishes to go from A to B, should be guided to use the mode and the route that impacts the capacity of the transport network the least, while at the same time his need for accurate ETA should be satisfied.

The user has to be guided but also informed in making the 'right choice' and she has to agree to follow the advice that the orchestrator (the public authorities) has set forward. The user as well as the service provider need to perceive this advice as a 'win' and not as a 'loss'. This is where new business models based on incentivisation enter traffic management. Incentivisation in influencing user behaviour in support of traffic management plans that enhance priorities such as load balancing or geo-fencing according to public sector set targets is key at both urban and motorway settings[93]. Local, national and regional governments should be supportive of these kind of initiatives. Both mobility patterns and human behaviour need to be studied in order to understand how to best nudge people's behaviours towards their use of the various modes of mobility.

Managing the mobility network according to the same principles upon which interactive traffic management (TM 2.0) is set up, namely trust and co-opetition, will make the transport network more flexible in accommodating services for integrated synchro-modal systems (all transport modes interchanging in real time). The connected user will be nudged into making informed decisions and will herself be willing to contribute to the optimisation of the entire transport network. "With the proliferation of digital technologies and the emergence of the connected traveller it will be easier to influence real-time demand by shifting demand in time (out of peak hours) and space (to alternative locations or routes through intelligent applications and user information services. Integrated urban traffic management and mobility information systems can contribute significantly to optimising transport flows through cities and in rural regions"[94].

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[92] Task Force 21: TM 2.0 - Multimodal mobility (07/09/2020) (https://tm20.org/wp-content/uploads/2020/10/TM-2.0-Maas-Alliance-report-for-Task-Force-on-Multimodal-mobility-final....-4.pdf)

[93] For an example of a motorway use case on influencing user behavior through incentivisation please see *URSA MAJOR Evaluation Report Avoiding rush hour 010 Project reference: Subactivity 3.2 Project location: Rotterdam region, The Netherlands (the* Spitsmijden 010 project 2013-2014) (https://www.its-platform.eu/wp-content/uploads/ITS-Platform/EUEIPBook/EU EIP_UM1_3.2_Avoiding_Peak_hours_A15_v1.0.pdf) and the proof of TM 2.0 concept project: SOCRATES 2.0 (2017-2020) and more specifically the case of Antwerp. Deploying interactive traffic management in the Antwerp ring incentivised users as well as service providers in adhering to the TMC routing advice (https://socrates2.org/activities/antwerp).

[94] COMMISSION STAFF WORKING DOCUMENT Towards clean, competitive and connected mobility: the contribution of Transport Research and Innovation to the Mobility package, Brussels, 31.5.2017 SWD(2017) 223 final (http://edz.bib.uni-mannheim.de/edz/pdf/swd/2017/swd-2017-0223-en.pdf) p.55.

As shown in Figure 12.5 below, interactive traffic management is part of the multimodal network management (MNM).

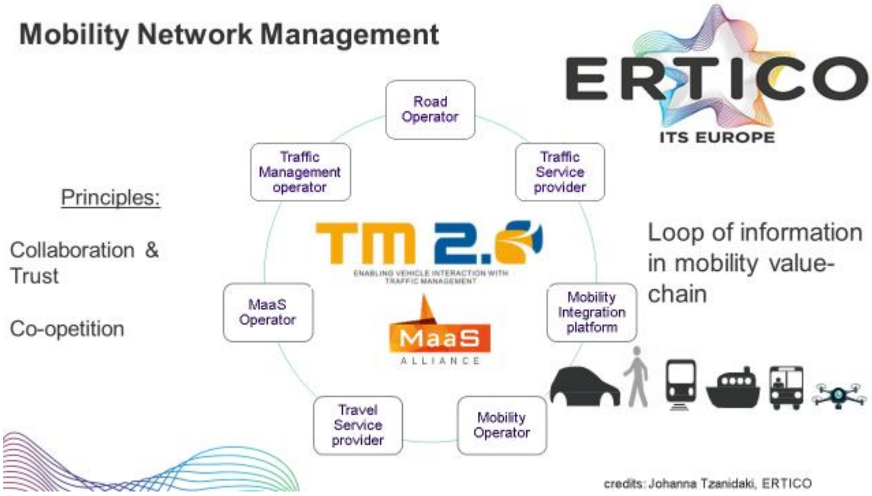


Figure 12.5: Mobility Network Management

How does Mobility Management relate to the high priority of safety for all? If capacity levels drop on the road network (because of an accident or other incident) traffic management measures alone cannot solve the issue. MaaS operators and service providers however, are in a position to channel travel demand into (a) different travel mode(s) in order to optimise the flows within the network. Orchestrated action by all stakeholders involved, will alleviate the burden of traffic congestion on the road network and distribute users in an optimal way that will keep road transport unclogged and, of course, safer. Another example is that traffic managers increasingly use geo-fencing to control road traffic passing through designated parts of a network (i.e. residential/school areas, high polluting zones, hospital areas), MaaS operators can also enable the provision of geo-fencing by promoting sustainable modes to pass through such areas. It is the stakeholders in mobility working in synergy that will enhance and ensure the safety of the Mobility system.

MaaS Service Providers may have a similar role to the one the Traffic Service Providers have in TM 2.0 scenario, but instead of “Enabling vehicle interaction with traffic management” (which is the current aim of TM 2.0), they will be “Enabling Mobility User interaction with traffic management”, leading to a new TM 2.0 paradigm (TM4.0!)

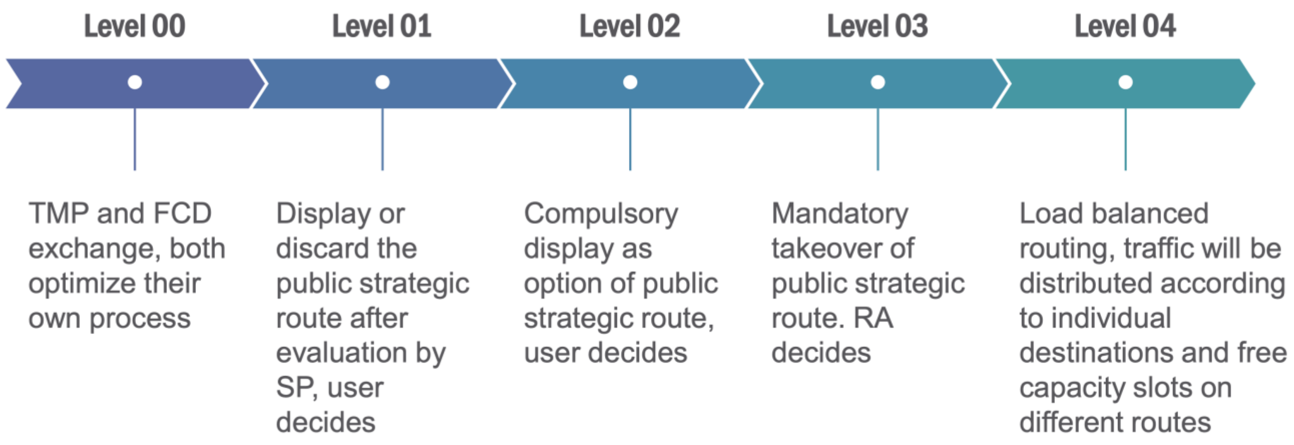
For this target to be materialised, there needs to be a trade-off between all the key elements of a Multimodal Mobility Management ecosystem such that each stakeholder understands that they can participate but their results may not be their individual optimum, but from a city-wide or motorway perspective the combination of the collective will have the effect of increasing the effectiveness of all mobility. In turn, each stakeholder may receive ancillary benefits of being better informed or having increased levels of planning and data to provide higher degrees of certainty on the execution of their customer journeys to specific schedules.

Traffic management centres can use the direct access that service providers have in vehicles and users and succeed in influencing user behaviour by advising on alternative routing, as shown in figure 12.6 below.

A closed road is on your planned route, would you like to avoid this road?

Figure 12.6: using in-car systems to influence user behaviour

The model of TM 2.0 on advanced traffic management, does not grant the exclusive power to the public authority to determine and impose the routing a user should follow. The entire concept of TM 2.0 is based on the cooperation between the Traffic Management Centre and the Service Provider with whom important information, such as traffic management plans are discussed and shared. The cooperation levels between TMCs and service providers and at which level the guidance provided by the TMC becomes obligatory (to be communicated to the user as mandatory routing advice) can be seen in the figure below.



Level 00	Level 01	Level 02	Level 03	Level 04
TMP and FCD exchange, both optimize their own process	Display or discard the public strategic route after evaluation by SP, user decides	Compulsory display as option of public strategic route, user decides	Mandatory takeover of public strategic route. RA decides	Load balanced routing, traffic will be distributed according to individual destinations and free capacity slots on different routes

Abbreviations: FCD = Floating Car Data; SP = Service Providers; RA = Road Authorities

Figure 12.7: TM 2.0 Cooperation levels among Traffic Management Centres and Service Providers

Accordingly, the user of the mobility network will always have open options on her choice of mobility mode and destination but will be asked to comply with compulsory routing (and mode use), when need be. The scheme is based on the understanding that most, if not all, users are primarily interested in reaching their destination on time, not really minding about routing, if there is no desired stop in between A and B.

12.6 Environmental traffic management - a desirable conclusion

As discussed in this chapter, traffic management has evolved its focus from the traditional planning of traffic lights on intersections and guidance of traffic via Variable Message Signs (VMS) and signals into a multi-level discussion amongst traffic manager operators, city planners, automotive engineers, decision-makers, economists and, most importantly, public authorities. As the priorities and targets of public authorities are changing, so will the user groups that demand to be prioritised in traffic, if the public authorities wish to stay true to their targets of ‘better quality of life’ for the citizens and ‘seamless and active mobility’. More and more cities will consciously seek to prioritise in the future pedestrians, bicycle users and other active road network users versus the vehicle users that have been prioritised in the past and traffic management operations are ready to address the challenge.

Through the interviews that ERTICO is conducting since May 2020 under its City Moonshot Initiative, findings show that safety and efficiency are being put on an equally high priority as sustainability and climate-friendly transport actions. Traffic managers and transport planners from 70 European out of 100 cities interviewed around the globe has stated that they plan to take action by establishing specific bicycle lanes (78%); continuing their investment in public transport (66%); establishing charging infrastructure for e-vehicles (63%) and developing a transport action plan (59%) for climate emergencies.

The traffic industry is already responding to this with traffic management products that work on the basis of the priorities selected by the public authorities and by ensuring that the traffic is guided in line with targets such as low carbon emissions. Using speed advice and parking availability, geo-fencing measures and recommendations on (eco) routes, public authorities in cooperation with service providers can directly emancipate the user to select the route that corresponds to the optimal environment-friendly option.

According to the TM 2.0 concept of interactive traffic management, when a city geo-fences its centre as a low emission zone during certain times of the day or even during certain days in a month, all service providers are informed and aware so as to not route their users through this zone, even if it means that their customer will have to delay their arrival at their destination by 20 minutes. According to the TM 2.0 scheme of cooperation, the city does not necessarily have to enforce this with a law or regulation. Well-discussed and agreed traffic management plans and strategies that involve all traffic stakeholders, suffice. In the much evolved concept of multimodal mobility management, the mobility stakeholders, be they mobility operators or service providers, will be aware of the city priority to geo-fence the centre and will follow suit on the city targets by means of rerouting or by providing alternative low emission mode advice to be followed by mobility users.

Through dialogue and cooperation between traffic stakeholders (public and private) traffic management can more efficiently prioritise on reducing climate impact while enhancing safety. These priorities are now becoming the responsibility of all mobility stakeholders and not only those of the public authorities. The Mobility Network optimisation is an ambition to which, all traffic stakeholders are called to contribute. The new cooperative approaches developed by the TM 2.0 ERTICO Innovation Platform promote the deployment of an interactive traffic management system, where the collective interest in safe, efficient and, equally importantly, sustainable transport are perfectly aligned. Climate targets are a priority for which the responsibility to reach them rests in how effective the cooperation of traffic stakeholders is.

Environmental traffic management takes traffic and mobility to the dimension of political prioritisation of climate friendly transport and that can be a plausible conclusion on the future of traffic management - for now.

13 Physical and Digital Infrastructure Support for Automated Driving

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13.1 Automated driving

Automated driving has been developing fast during the last decades. SAE[95] has determined five levels of automated driving on top of Level 0 No driving automation. The levels of automation are:

1. Driver assistance
2. Partial driving automation
3. Conditional driving automation
4. High driving automation
5. Full driving automation

The taxonomy of driving automation is based on the responsibilities for the Dynamic Driving Task (DDT) including Object and Event Detection Response (OEDR) as well as the requirements for Operational Design Domain (ODD) as shown in Table 13.1.

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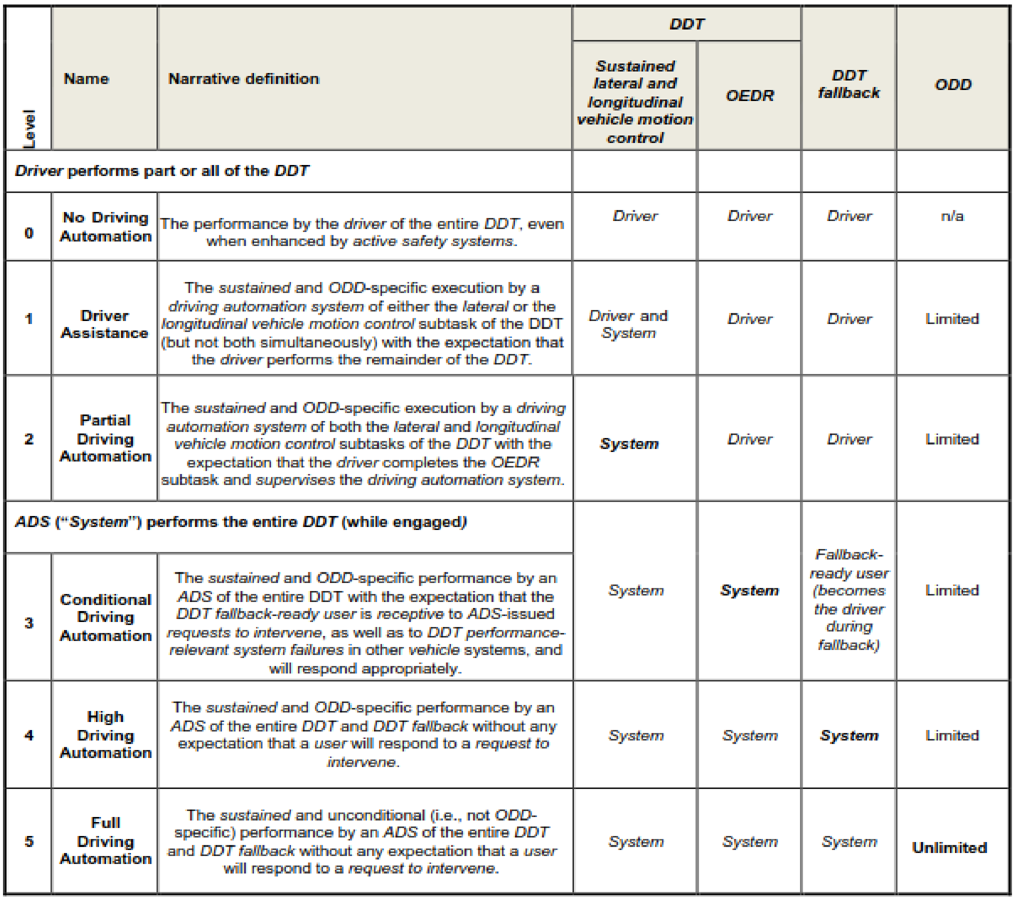
[95] SAE (2021). J3016 - Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. SAE APR2021. Revised 2021-04. 41 p.

Table 13.1: Levels of driving automation (SAE 2021)



Level	Name	Narrative definition	*DDT*		*DDT fallback*	*ODD*
			Sustained lateral and longitudinal vehicle motion control	*OEDR*		
Driver* performs part or all of the *DDT						
0	**No Driving Automation**	The performance by the *driver* of the entire *DDT*, even when enhanced by *active safety systems*.	*Driver*	*Driver*	*Driver*	n/a
1	**Driver Assistance**	The *sustained* and *ODD*-specific execution by a *driving automation system* of either the *lateral* or the *longitudinal vehicle motion control* subtask of the DDT (but not both simultaneously) with the expectation that the *driver* performs the remainder of the *DDT*.	*Driver* and *System*	*Driver*	*Driver*	Limited
2	**Partial Driving Automation**	The *sustained* and *ODD*-specific execution by a *driving automation system* of both the *lateral* and *longitudinal vehicle motion control* subtasks of the *DDT* with the expectation that the *driver* completes the *OEDR* subtask and *supervises* the *driving automation system*.	***System***	*Driver*	*Driver*	Limited
***ADS* ("*System*") performs the entire *DDT* (while engaged)**			*System*	***System***	*Fallback-ready user (becomes the driver during fallback)*	Limited
3	**Conditional Driving Automation**	The *sustained* and *ODD*-specific performance by an *ADS* of the entire DDT with the expectation that the *DDT fallback-ready user* is *receptive* to *ADS*-issued *requests to intervene*, as well as to *DDT performance-relevant system failures* in other *vehicle* systems, and will respond appropriately.				
4	**High Driving Automation**	The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	***System***	Limited
5	**Full Driving Automation**	The *sustained* and unconditional (i.e., not *ODD*-specific) performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	*System*	**Unlimited**

Currently we have several Level 0, 1 and 2 systems available on the market as well as a few Level 4 systems as visualised in Figure 13.1.

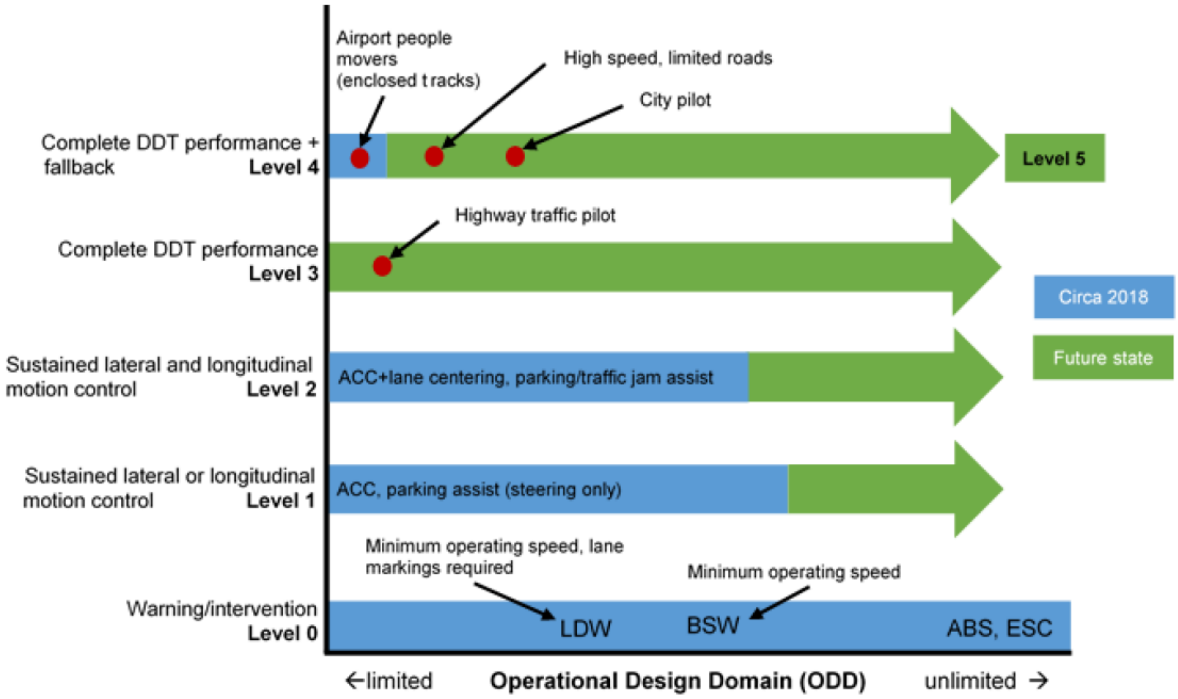


Figure 13.1: Automated driving use cases availability according to automation level and ODD limitation. (SAE 2021)

It is foreseen by Aigner et al.[96] (that several Level 3 and especially level 4 vehicles will be available in the markets by 2030. Level 5 without any ODD restrictions is not expected to be available in the foreseeable future.

13.2 Operational design domain ODD

As is obvious from the previous paragraphs, ODDs play a major role for automated driving. ODD is defined as operating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics. Hence, the automated vehicle is capable of operating in the automated mode only within its ODD.

If the vehicle driving in automated mode approaches the end of the ODD it will alert the driver of the situation. If the vehicle is a Level 3 vehicle and the driver does not take over the control of the vehicle, the vehicle needs to make an emergency stop. If the vehicle is a Level 4 vehicle, in a similar case the vehicle initiates a minimal risk manoeuvre to ensure the safety of the vehicle occupants. The terminations of ODD will thereby break the continuity of the journey and may prevent long continuous journeys in automated mode. For customers, the continuity of smooth automated travel is something to hope for. Thereby, for the manufacturers of automated vehicles (AV) and developers of automated driving systems as wide ODDs as possible are also a competitive asset.

The EU EIP[97] and MANTRA[98] projects determined the road operator relevant ODD attributes according to table 13.2.

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[96] Aigner, Walter; Kulmala, Risto; Ulrich, Sandra (2019): Vehicle fleet penetrations and ODD coverage of NRA-relevant automation functions up to 2040. MANTRA: Making full use of Automation for National Transport and Road Authorities – NRA Core Business, Deliverable 2.1. https://www.cedr.eu/download/D2.1-Vehicle-fleet-penetrations-and-ODD-coverage.pdf

[97] Amelink, Maarten; Kulmala, Risto; Jaaskelainen, Juhani; Sacs, Ian; Narroway, Steve; Niculescu, Mihai; Rey, Laura; Alkim, Tom (2020). Road map and action plan to facilitate automated driving on TEN road network – version 2020. EU EIP SA 4.2 Deliverable Version 6.0, 20 November 2020. 95 p. https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/AutomatedDriving/EU%20EIP_SA42_%20Deliverable%20_Task_3_2020_Road_Map_and_Action_Plan_v6.0.pdf

[98] Ulrich, Sandra; Kulmala, Risto; Appel, Kristian; Aigner, Walter; Penttinen, Merja; Laitinen, Jukka (2020). Consequences of automation functions to infrastructure. MANTRA: Making full use of Automation for National Transport and Road Authorities – NRA Core Business, Deliverable 4.2. 134 p. https://www.mantra-research.eu/wp-content/uploads/2020/05/MANTRA_Deliverable_D42_Final.pdf

Table 13.2: ODD attributes relevant for the road operators (EU EIP, MANTRA)

ODD attribute	Physical / Digital infrastructure	Static / Dynamic
Road	Physical	Static
Speed range	Physical	Static
Shoulder or kerb	Physical	Static
Road markings	Physical	Static
Traffic signs	Physical	Static
Road equipment	Physical	Static
Traffic	-	Dynamic
Time including light conditions	-	Dynamic
Weather conditions	-	Dynamic
HD map	Digital	Static
Satellite positioning	Digital	Static
Communication	Digital	Static
Information system	Digital	Static
Infrastructure maintenance	Physical/Digital	Dynamic
Fleet supervision	Digital	Dynamic
Digital twin of road network	Digital	Dynamic

Many attributes are related to infrastructure, mostly the physical infrastructure. Also aspects of the digital infrastructure are relevant for the ODDs. Concerning the nature of the attributes, most of them are considered as static with regard to the availability of the service behind the attribute. In many cases, the service content itself can be quite dynamic, for example up-to-date information about a VMS from an information service provided in real time via the communications service to a vehicle accurately located just at the moment utilising a newly updated HD map.

13.3 Infrastructure support

As infrastructure attributes are important ODD attributes, at the same time infrastructure is clearly facilitating automated driving as long as automated driving does not reach Level 5 where it is not depending on ODDs anymore.

Thereby road authorities and operators are discussing how their infrastructures are supporting automated driving and studying concepts like ISAD (Infrastructure Support for Automated Driving) based on Lytrivis et al.[99] and LOSAD (Level Of Service for Automated Driving) based on Garcia et al.[100]. In both of these concepts, the infrastructure support is categorized in five levels, from A to E where A is the highest support level. It is determined as a function of how

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[99] Lytrivis, Panagiotis; Manganiaris, Stamatis; Reckenzaun, Jakob; Solmaz, Selim; Protzmann, Robert; Adaktylos, Anna-Maria; Wimmer, Yannick; Atasayar, Hatun; Daura, Xavier; Porcuna, David (2019). Infrastructure Classification Scheme. INFRAMIX – Road INFRAstructure ready for MIXed vehicle traffic flows, Deliverable D.5.4. 6/12/2019. 49 p. https://www.inframix.eu/wp-content/uploads/D5.4-Infrastructure-Classification-Scheme.pdf

[100] Garcia, Alfredo; et al. (2021). PIARC Special Project "Smart Roads Classification". Proposal. 26 May 2021. 34 p.

ready and able the road infrastructure is to support automated driving. The ISAD levels proposed are focused on the digital infrastructure and especially to connectivity and availability of data, but these have been extended by Kulmala and Innamaa[101] to cover also physical infrastructure, traffic management and other support on interurban motorways. Table 13.3 shows their proposal for an updated ISAD classification.

Table13.3: Service level definitions for all attribute categories.

ISAD service level	**Physical infrastructure**	**Digital infrastructure**	**Environmental conditions**	**Dynamic elements**
E: Conventional (physical) infrastructure only, no AV support	Physical infrastructure designed according to current design guidelines (made for manually driven vehicles)	No support from digital infrastructure, i.e. road geometry and road signs have to recognised by AVs on their own	Road side stations may measure environmental condition but no direct access to the data available	Traffic management provided according to current operational guidelines
D: Static digital information / map support	Infrastructure easily perceived and identified by AVs	Digital map data (incl. static road signs) complemented by physical reference points; Traffic lights, short-term roadworks and VMSs have to be recognised by AVs on their own	Historic information on environmental conditions available in machine readable format	Traffic management measures and plans provided in a way correctly perceived by AVs, self-diagnostic TMC hardware
C: Dynamic digital information	Enhanced physical infrastructure for AVs with regard to improved infrastructure maintenance	All static and dynamic information can be provided to the AVs in digital form; AVs receive infrastructure support data	Infrastructure-based weather information available	Dynamic traffic and incident management including connectivity, self-healing TMC hardware
B: Cooperative perception	Improved physical infrastructure for AVs with regard to MRMs	Infrastructure is capable of perceiving microscopic traffic situations; AVs receive infrastructure support data in real time (C-ITS Day-1)	Detailed cooperative weather information (V2I): obtained via processing and sharing perception sensor findings by vehicles present on the particular road segment and infrastructure-based information	Enhanced dynamic traffic and incident management, self-learning TMC hardware
A: Cooperative driving	Improved physical infrastructure for AVs with regard to positioning support and vehicle supervision	Infrastructure is capable of perceiving vehicle trajectories and coordinate single AVs and AV groups; Infrastructure helps to coordinate vehicle manoeuvres to optimise traffic flow (C-ITS Day-2+)	Individual trajectory recommendation available taking into account the prevailing environmental conditions	Local traffic management arrangement provision for AVs, self-management TMC systems

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[101] Kulmala, Risto; Innamaa, Satu (2021). Service level framework for automated road transport. Finnish Transport Infrastructure Agency. Working Report 15 September 2021. 36 p.

It should be pointed out that these infrastructure support levels from A to E have been developed mainly for the benefit of road operators to describe, discuss and understand the requirements of higher levels of automated driving towards the road infrastructure and road operators. These are also useful for higher-level strategic discussions with the automated vehicle industry. In real life daily operations the automated vehicles need, instead of the support levels A…E, detailed information of the existence and value of the physical and digital infrastructure attributes essential to their specific ODDs.

13.4 Physical Infrastructure

The physical infrastructure elements utilised by also lower levels of automated driving are various road guidance systems such as lane and other road markings. Specific use cases such as truck platooning and automated shuttles or higher levels of automated driving, bring into the picture more extensive requirements for physical infrastructure support. An example of the latter is the issue with minimal risk manoeuvres (MRM). There is a concern that minimum risk manoeuvres could cause a lot of safety and throughput problems for the road operators, unless such manoeuvres can be accomplished in a safe and efficient manner considering the road operator concern. It should also be noted while the minimum risk manoeuvres are expected to be quite rare events, the probability of their occurrence is still quite uncertain. It is likely that safe MRMs also require physical road infrastructure space such as a wide shoulder or specific widening. The alternative would be to prohibit the use of highly automated vehicles in automated mode on safety- and throughput-critical road sections.

The automated driving use case and operating environment (e.g. interurban motorway, city centre street, parking facility, port terminal) all set specific requirements on the physical infrastructure demands. Table 13.4. lists the relevant physical infrastructure attributes for infrastructure support on an interurban motorway.

In many European motorways, most of the attributes are of sufficient value to support automated driving, but there are also cases of insufficient service. Some motorways have too narrow (<2 m) paved shoulders outside in order to facilitate safe stopping as an MRM. Confusing lane markings can exist especially after road works, and the road works themselves are often marked in a non-standard way likely not easily detected and interpreted by the highly automated vehicles. Landmarks offering support for accurate positioning of the vehicle do not exist in many areas with problematic satellite positioning accuracy.

The recommendations for the threshold values for each of the attributes are proposed in detail by Kulmala and Innamaa (2021).

13.5 Digital Infrastructure

Digital infrastructure is the most important aspect of infrastructure support providing major new aspects of infrastructure support on top of the physical infrastructure. The three key elements of the digital infrastructure are the digital twin, connectivity and positioning. The digital twin is proving to the automated vehicle the digital image of the road transport system including the physical infrastructure and in addition its environment, land use, available services, rules and regulations, real-time data of traffic, traffic management, weather conditions, etc. An important element and basis of it is the HD map. Connectivity is widely regarded as a necessity for highly automated vehicles. The basic communication types will most likely still be vehicle to vehicle short range, vehicle to infrastructure short range, and vehicle to infrastructure medium/long range. These will provide the connectivity for the automated vehicle facilitating its electronic horizon towards the route ahead along its way. The accurate positioning of the vehicle is essential for the vehicle to link correctly with the digital twin and to navigate safety in the physical road infrastructure. Table 13.5 shows the attributes of the digital infrastructure.

Table 13.4: Physical infrastructure attributes relevant for support of highway autopilot on an interurban motorway, their definitions and relevance for automated vehicles. (Kulmala & Innamaa 2021)

Attribute	**Definition**	**Relevance**
Lane marking retroreflectivity	The visibility of the marking to human eye and vehicle sensors (mcd/lx/m^2)	Vehicle sensors such as cameras can use the marking for lateral positioning on the driving lane
Luminance contrast ratio	Luminance contrast ratio between the line and the surrounding pavement	As above; visibility of the marking with regard to the pavement itself
Lane marking consistency	Continuity of markings, lack of any misleading markings on pavement	Avoidance of misinterpretations by AV software
Bearing capacity of lane	Ability of road to carry moving vehicles without damage	Important for platooning of heavy goods vehicles
Shoulder width	Width of paved area on side of driving lane	Provision of room for stopping due to MRM. Relevant sub-attributes: - outside - inside
Shoulder bearing capacity	Ability of shoulder to carry moving vehicles without damage	Important for MRM of heavy goods vehicles and their platoons
Widening or lay-by	Widening of drivable area or provision of a separated area linked to the drivable area lane	Can be used for MRM, picking up or dropping off passengers, and waiting for or provision of platoon coupling
Drivable area induced road surface condition	The condition of the road surface with regard to damage and wear	Safety of road use
Landmarks	Fixed structure (building, street light pole, bollard, gantry or specific conspicuous landmark)	Supporting GNSS or other form of ego-positioning for AVs
Construction site detour	Marking of detour in case of road closure due to road construction works	Indication of need to change route i.e. to turn to another road
Road works	Marking of the road works site and the intended trajectories	Indication of roadworks and need to adapt speed and trajectory

Table 13.5: Digital infrastructure attributes relevant for support of highway autopilot on an interurban motorway, their definitions and relevance for automated vehicles. (Kulmala & Innamaa 2021)

Attribute	**Definition**	**Relevance**
Cellular communication	4G, fourth generation of broadband cellular network technology 5G, fifth generation of broadband cellular network technology	Can be used for connectivity between infrastructure and vehicle. Relevant sub-attributes include e.g. number of redundant cellular networks
Short-range communication (ITS-G5, C-V2X, etc.)	Wireless communication technology that enables vehicles to communicate with each other and other road users directly, without involving cellular or other infrastructure	Can be used for connectivity between infrastructure and vehicle as well as between vehicles
Communication performance	Overall performance of communication (potentially using multiple technologies or networks) in a single location • Download and upload speed (Mbit/s) • Latency (s) • Reliability	Performance describes the overall capability and reliability of communication
GNSS	Satellite positioning, accuracy affected e.g. by • Dual frequency receiver • Localisation assistance services	Positioning required for automated driving
HD map	High-definition map which includes e.g. following attributes • Road type and geometry • Traffic signs • Lay-by and parking areas • Bearing capacity	HD map required for automated driving
Cooperative ITS (C-ITS) service or similar	Immediate collision warnings	Information provided by C-ITS or similar services enables early TOR and supports safe driving in special circumstances
	Event, incident and other hazardous location information	
	Road works information	
	In-vehicle signage	
	Information on weather conditions	
Traffic flow information	Traffic flow rate, mean speed, % of HGVs	Traffic status in surrounding road network
Routing advice		Supports routing when road is blocked
Digital traffic rules and regulation		Prevailing regulation
Availability of physical and digital infrastructure	Information of the availability of ODD related infrastructure attributes and their values,	Information of future ODD availability; Framework for remote guidance, availability of infra for MRM
Traffic management plans and real time guidance		Routing and behavioural plans
ODD/ISAD management information	Sharing of ODD- and ISAD-status related information between AVs and traffic managers, provision of infrastructure support tools to extend ODD when/where needed and to facilitate and manage MRMs	Keeping both AVs and traffic managers aware of the availability or lack of ODD, and the automated use of AVs on the network, and use of MRMs

Many interurban motorways in Europe have 4G cellular coverage, but only a few offer short-range communications. Specific automated driving related HD maps cover only some parts of the European road network. Satellite positioning is available but usually not accurate enough for automated driving. Real-time event, traffic and road weather information is available on many motorways but the quality needs improvement. Digitised rules, regulations, and traffic management plans with secure access points need to be developed.

13.6 Other Infrastructure related support

The main dynamic element related to the infrastructure affecting the ODDs is traffic management. Table 13.6 compiles the attributes related to traffic management.

Table 13.6: Traffic management attributes relevant for support of highway autopilot on an interurban motorway, their definitions and relevance for automated vehicles. (Kulmala & Innamaa 2021)

Attribute	**Definition**	**Relevance**
Monitoring systems/ services	Infrastructure-based traffic, weather, and environment monitoring solutions	Provision of environmental information to AVs' local dynamic maps
Traffic management services	Existing traffic management services on the road section	Prevailing driving regulations
Variable speed limits	Maximum driving speed adapted to current conditions	Prevailing speed limits
Tunnel management services	Services to ensure safe and efficient use of tunnels	Safe driving through tunnels
Incident management	Services to detect, inform of, control traffic at, rescue victims of, and clear road incidents and their sites	Mitigation of safety, efficiency and environmental consequences of incidents to AVs
Road works management	Management of traffic in connection with both fixed and mobile road works	Ensuring safe passing of road works
Traffic management centre systems	Operation of traffic management services 24/7	Real-time reaction to any events, incidents and other disturbances on the route ahead

Traffic monitoring and management services are being provided widely on the European motorways, but real-time information on traffic management related actions is not available in digital form. Incident and road works management processes and practices need to be developed to address also connected and automated vehicles, and in general the traffic management systems should be further automated to improve the quality and response speed of traffic management actions.

13.7 Future of Infrastructure Support

Information on ODD requirements from CAD developers is still limited unfortunately. Therefore, the identified ODD requirements are based on the work carried out in the CCAM platform and projects such as EU EIP, MANTRA, INFRAMIX, AUTOMOTO and expert views. The evolution of the ODDs is driven by customer demand and enabled by the improvement of vehicle sensors – for instance, sensors being able to deal with different kinds of weather conditions – and vehicle software – for instance, AI being able to deal with safe manoeuvring of the vehicle also in interaction with vulnerable road users in complicated urban environments. The technological development in the areas of sensors and software is currently very fast, and also hard to predict with any certainty. At the same time automated vehicle manufacturers are regarding their ODD properties and plans as sensitive strategic information not to be shared even with neutral stakeholders such as national road authorities.

Hence, the road authorities and operators are forced to proceed with only educated guesses about the ODDs of the Level 4 vehicles entering the market in the near future. However, developments are already ongoing in crucial areas with regard to the future physical and digital road infrastructure development and investment needs. First, Minimal Risk Manoeuvres (MRMs) are currently worked upon in standardisation with little road operator participation while MRMs can in fact have major impact on the planning and building of the physical road infrastructure with potentially huge investment consequences. Second, providing input and maintaining digital twins may turn out to be highly demanding in terms of both human and monetary resources as well as secure, especially in keeping the twins updated in real time. Specific attention should be given to the development of the digital twins so that their maintenance and operation is as efficient and secure as possible.

13.8 Prioritising Infrastructure support investments

The European CCAM Platform[102] provided a platform for discussion on the infrastructure support topic in its Working Group on Physical and Digital Road Infrastructure. The working group provided a number of recommendations described below.

Investments in digital and operational infrastructure should increasingly complement and strengthen investments in physical infrastructure. The recommendation is that within an overall increase of investments for transport infrastructure the share of digital and operational infrastructure out of all road infrastructure increases as well. (EC 2021)

Completing the digital infrastructure, as in a high-quality digital twin of all infrastructure, complemented by cooperative intelligent transport systems in relevant areas, will take time. Setting up the necessary process to keep it up-to-date will too. Investments in new transport infrastructure should always include the relevant digital components. (EC 2021)

As the transition phase will be long, mixed traffic will exist for multiple decades, infrastructure improvements that also benefit other road users will make for a much better return on investment. Hence, to make tangible progress early on, as well as prepare for a rapid deployment of automated mobility services, one should prioritize investments that benefit both human driven and automated vehicles. (EC 2021)

Digital infrastructure already enables dynamic traffic management today. For example, variable message signs are used for dynamic setting of speed limits or direction of travel. When available, this information should be replicated in the digital twin (e.g. via a National Access Point), making it available for HD maps, as well as being shared through C-ITS messages, reducing latency and creating redundancy. The relevant public authority (local, regional or national) should take responsibility for all representations of PDI data in equal manner. (EC 2021)

To maximise its potential in supporting CCAM, the digital and operational infrastructure needs to be reliable, up to date, trusted and secure. Though particularly for C-ITS some of these elements are already addressed, the recommendation remains that digital infrastructure needs to fully embrace functional safety. (EC 2021)

The WG also formulated recommendations related to specific and challenging situations. Such situations are road works, complex intersections and crossings, and areas posing particular challenges to ego-localisation[103], such as underground parking facilities or urban canyons, or to bridging locations with limited availability of GNSS signals, such as tunnels.

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[102] EC (2021). Draft final report of the single platform for open road testing and pre-deployment of cooperative, connected and automated and autonomous mobility platform (CCAM Platform). European Commission. Brussels June 2021. 160 p.

[103] Ego-localisation means the positioning of the automated vehicle itself

14 Integrating C-ITS into Road Operators' Day-to-Day Business

Authors: Holger Drees, Torsten Geissler, Farzin Godarzi (BASt)[104]

14.1 Introduction

As Cooperative Intelligent Transport Systems (C-ITS) are currently making the transition from large-scale testing stages to widespread use, their importance to road authorities and operators is also increasing. C-ITS is maturing to a renowned technology to improve safety and efficiency of road traffic and hence becoming part of the toolkit of road operators to reach their core goals. Acknowledging this, the European ITS Platform EU EIP dedicated a separate sub-activity to this topic.

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

The C-ITS sub-activity had the special focus on C-ITS deployment. Besides that, there have been synergies with other EU EIP activities which could be supported. C-ITS as a new option to communicate with the road users has been integrated into the Reference Handbook for harmonised ITS Core Service Deployment[105]. Concerning the quality of C-ITS services, a Quality Framework for C-ITS has been created as the quality frameworks have been well established for traditional ITS services before[106].

With the C-ITS flagship C-Roads, which was set up in the meantime and which has boosted the C-ITS deployment landscape, a collaboration was established to join forces.

The C-ITS related results are laid down in a total of eight deliverables (see Figure 14.1). As it becomes visible from the overview on deliverables and milestones, the nature of the C-ITS deliverables is mostly recurring by intention (draft – providing orientation, final – full deliverable). In so far, the Deliverables D2 and D6 as well as D3 and D7 correspond, as the arrows suggest. It is also worth mentioning that the 2017 and 2019 workshops organised in collaboration with C-Roads are documented as D4 and D5. In addition, the experts have

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[104] The authors want to thank the following contributors to the results of the sub-activity: Petri Antola, Anders Bak Sørensen, Sandro Berndt-Tolzmann, Axel Burkert, Carole Ciliberti, Claudio Gombi, Ulrich Haspel, Ilkka Kotilainen, Stephanie Metzner, Katharina Nagel, Elias Nassif, Fabrizio Paoletti, Clas Roberg, Ludovic Simon, Mikko Tarkiainen, Onno Tool, Carlos Viktorsson, Paul Wadsworth.

[105] European ITS Platform – EU EIP (2021): Reference Handbook for harmonised ITS Core Service Deployment in Europe, https://www.its-platform.eu/reference-handbook.

[106] Lubrich, P., T. Geissler, Risto Öörni, Leif Rystrøm (2021): Quality Package on C-ITS Information Quality, https://www.its-platform.eu/news-highlights-2020/#link1.

contributed cross-platform to the C-ITS webinar as part of the EU EIP ITS Web Forum (November 2021) and the C-Roads Evaluation and Assessment Workshop (December 2021).

The focus of this chapter is on the content of the final deliverables on implementation guidance, service implementation beyond initial deployment and recommendations for continuation of C-ITS deployment.

All in all, the sub-activity has fostered the knowledge exchange between EU EIP members, has collected experiences from the stakeholders with C-ITS pilots and deployments to develop guidance for further integration of C-ITS into day-to-day business of road authorities and operators. In this respect, cooperation starts with a common mindset of all involved actors so the activity aimed for bringing interested people together in order to foster the knowledge exchange between all relevant stakeholders. From the collected knowledge, the most important issues and the need for guidance to the road operators were identified and tackled in guidance documents. This finally resulted in recommendations for the further deployment of C-ITS services.

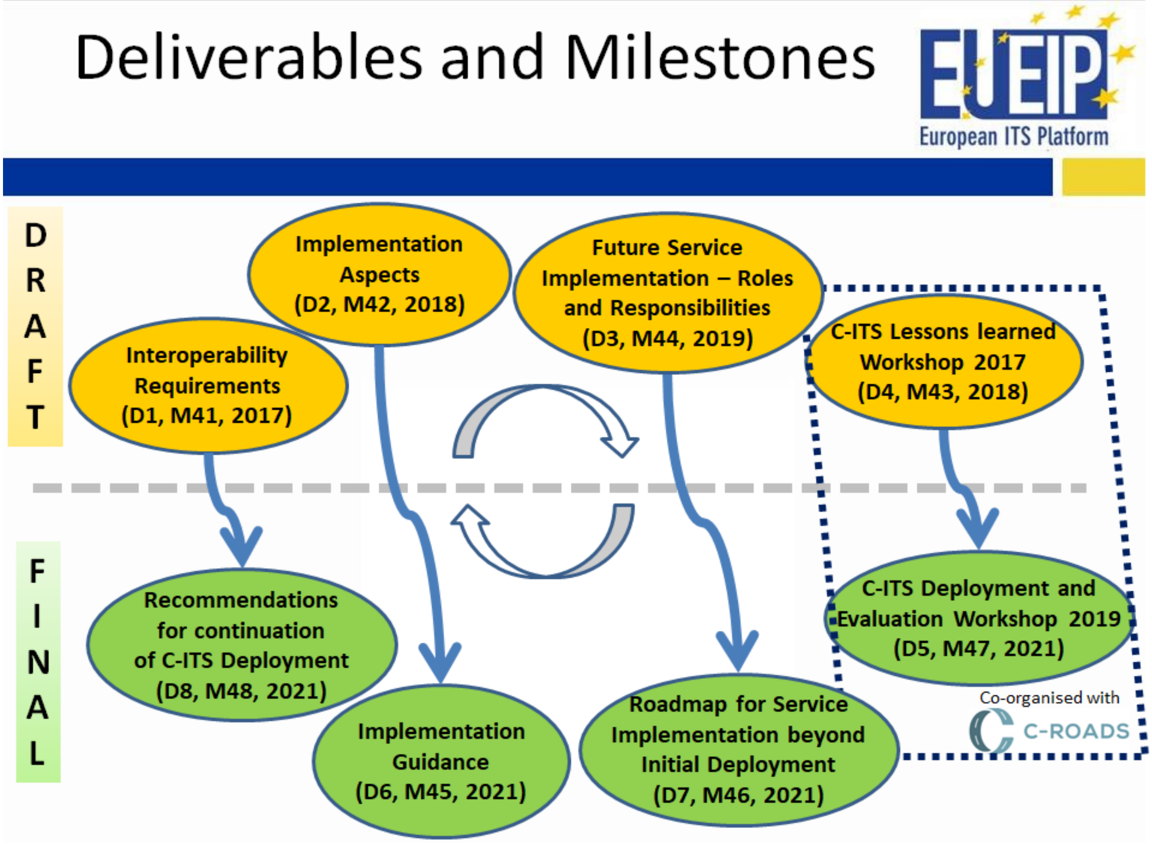

Figure 14.1: Results of the C-ITS experts work in the EU EIP C-ITS sub-activity

14.2 Foster Stakeholder Exchange

With the aim of creating a proper environment for the harmonisation of existing and future ITS and C-ITS services as well as ensuring continuity of high-quality services for European end-users, the European ITS Platform offers a flexible structure on the scope and level of participation to the Member States and beneficiaries. National ministries, road authorities, road operators and partners from the private and public sectors of almost all EU Member States and neighbouring countries have the possibility to choose between various activities and sub-activities, with different levels of involvement, acknowledging their different needs and degrees of maturity. Therefore, EU EIP brings together the majority of the European key players, cooperating not only to establish an open “forum” in order to provide valid contributions for future strategy and policy recommendations for better developments of ITS and C-ITS services along European road Corridors, but also organises different sets of workshops and webinars continually to address relevant topics. These include organisational and governance issues, information quality aspects of ITS and C-ITS, management of C-ITS-enabled data and lessons learned from C-ITS pilots and deployment initiatives.

Correspondingly, in order to lay down the collaboration and exchange in a more explicit and comprehensive way to accelerate and optimise current and future C-ITS deployments in Europe in a harmonised way, EU EIP collaborates closely with different C-ITS actors such as C-Roads Platform for the mutual benefit of both platforms. The collaboration note (2019) between the two platforms EU EIP and C-Roads reveals the involvement of organisations from 13 European countries in both platforms and further 7 European countries within C-Roads, which are working together with EU EIP via the CEF ITS Corridors. The key aspects in content of this collaboration is to provide guidance towards C-ITS deployment and implementation aspects of C-ITS services with infrastructure involvement, provide evidence of how real benefits for road authorities and local authorities can be provided and similarly guide them to relevant actors, projects and documents at European level concerning the implementation of C-ITS on a strategic level.

Figure 14.2: Left: Sharing real-world C-ITS pilot experience in Hessen. Right: In-vehicle view of the C-ITS service Maintenance Vehicle Warning of the C-Roads pilot Hessen.

14.3 Develop Guidance for C-ITS Deployment

In line with the sub-activity’s greater objective, a document has been developed under the title *Implementation Guidance for C-ITS Services with Infrastructure Involvement*. This document is intended to serve as a first starting point for road authorities and operators interested in integrating C-ITS services in their domains. With the various activities and pilots throughout Europe already active in implementing C-ITS services, this document aims to consolidate the experiences gained from addressing strategic challenges in technical, organisational and legal matters, amongst others, from a national but also cross-border perspective. Through an easy-to-navigate structure, the document can steer road authorities and operators to the relevant bodies, projects and documents on European level.

With the objective to accumulate the knowhow built by the diverse participants and activities of the European C-ITS initiatives, a comprehensive overview about sound common strategies for C-ITS service implementation, identified pitfalls and developed best practises to allow for maximum exploitation of the investments taken into problem solving on European level, shall be created. In the first part of the document, the topic of C-ITS is introduced from the perspective of road operators and highlights the related challenges as well as benefits from implementing C-ITS services compared to existing means of traffic management.

Based on reviewing existing approaches, EU EIP synthetises the complexity of C-ITS related decision processes to the abstract process model comprising the steps Decision, Design, Implementation and Operation ("DDIO" Model – see Figure 14.3, reflected a concept drafted by Wadsworth (2021)[107]). Within the first step, the transport policy objectives must be used to understand which C-ITS services are suitable and also as basis to devise methods suitable to tackle the challenges likely to arise with C-ITS implementations (e.g. privacy issues might be very important for local users and hence should be addressed by PR). It is essential to correctly identify user groups and especially also involve all contributing stakeholders, be they technical stakeholders or otherwise. The stakeholders and user groups should be carefully defined and amended as needed in case further C-ITS services shall be implemented. Technical and economic feasibility studies are to be subsequently executed to determine the viability of planned services under the specific regional and organisational ancillary conditions prevailing, concluding the first step. The original concept might be amended according to the results of these studies e.g. by principle inclusion of private co-financing.

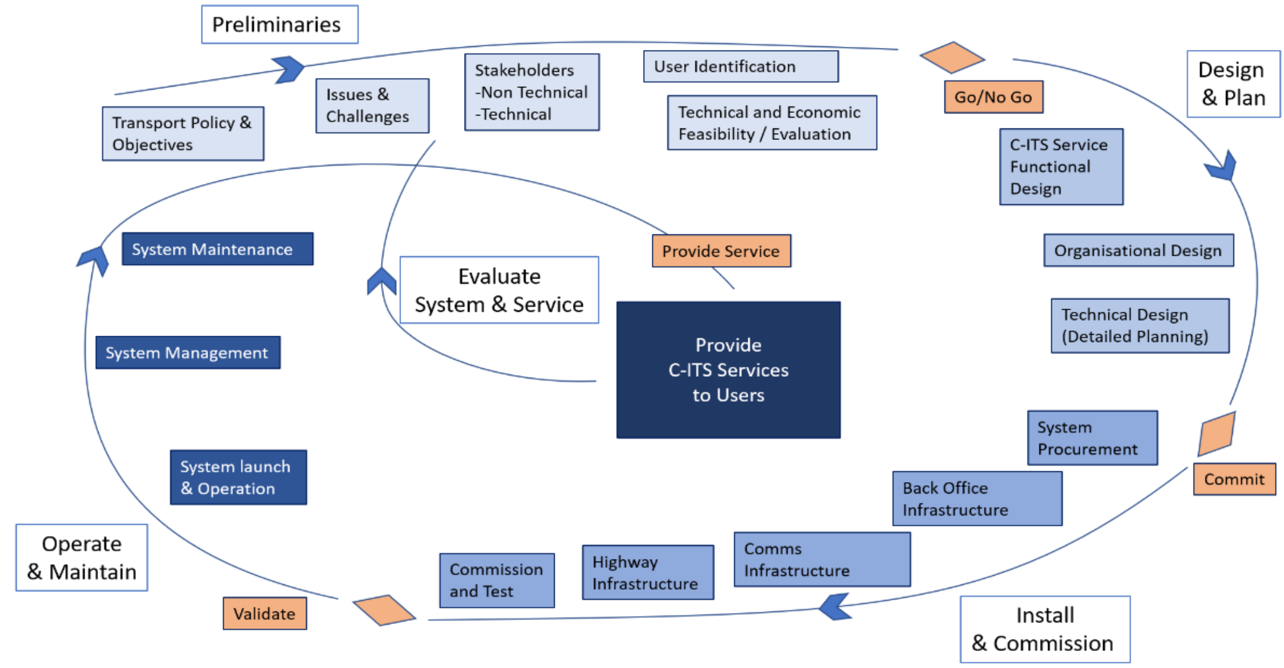

Figure 14.3: DDIO Model: Decision Design Implementation Operation

Pursuant to a positive conclusion of the first step, the services which should be implemented are to be specified in detail. This, of course, is based on the user groups identified and stakeholders involved in the first step. Contract templates and functional description as preparation for tendering actions are defined within this step, as are data management, tendering and certification processes.

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[107] Wadsworth, P. (2021), Integration into road operators' business, Presentation at the 6th Webinar of the Web ITS Forum, 05.11.2021, https://www.its-platform.eu/achievement/integrating-c-its-into-road-operators-day-to-day-business.

With this detailed commitment in place, system implementation is at hand. This task not only comprises the actual system procurement according to the procurement schemes defined within the second step, but also the setup of organisational and technical support structures vital to any upcoming operations. This step will involve a wide variety of actual tasks ranging from the setup of infrastructure such as RSUs to the implementation of a back-office support structure.

Once implemented, C-ITS service operation is required. Although C-ITS is new and highly complex technology, a high level of experience is available in the market concerning the launch and operation of complex technological services. Provided that the third step comprehensively defined the required system components, be they technology based or organisational, system operation should be stable.

However, the multiplicity of steps and components of different complexity required to set up C-ITS services hold significant challenges. Hence, in the second part, the *Implementation Guidance* contains a repository of important experiences in the different stages of implementing C-ITS services, including references to the relevant documents and specifications. For instance, the cooperation with the C-Roads platform builds the link to the pilot projects carried out in the various European Member States. With respect to this, a core asset of the C-Roads platform activities is the cross-border harmonisation and interoperability of the numerous deployments. This enables the meticulously developed requirements for cross-border interoperability to be adopted by interested stakeholders who need to consider the holistic integration of their planned operations.

Additionally, in the scope of the C-ITS Corridor project, German, Dutch and Austrian road operators together with the automotive industry, started the gradual introduction of cooperative systems in Europe. In the course of this, procedures for testing under real traffic conditions have been defined and coordinated; technical solutions for data communication have been standardised and non-technical aspects such as the organisational structures and security measures have been drafted, amongst others[108]. With the development, test and trial phases successfully finalised and the rollout of the first C-ITS service *Road Works Warning* now underway, valuable references of the current best practices for the operation and maintenance of C-ITS services are contained in the *Implementation Guidance*.

Additional and more detailed information is provided in the third and final part of the document which updates the work of a preceding deliverable of this sub-activity[109]. It presents an overview of actors in the European C-ITS landscape – the 'Who is Who'. It continues in shortly describing major information sources within the different C-ITS clusters in Europe.

14.4 Further Deployment of C-ITS Services

Building on the successful piloting of C-ITS services and gradually moving towards regular operation, the large-scale deployment of services represents the next big step. C-ITS services deployment follows and still partly overlaps with the deployment of ITS services which are widely operated on the long distance as well as regional and municipal strategic road networks. At the same time, the next generation of technology, enabling Connected Cooperative Automated Mobility (CCAM), is already maturing in the research and development stage and will be demonstrated on large scale later in this decade. Any foresight on further C-ITS

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[108] Trost, T., M. Trempler, A. Reußwig, G. Riegelhuth, K. Sauer (2019), Workzone V2X trial – C-ITS Corridor, Intertraffic World Annual Showcase 2019.

[109] Tool, O., S. Berndt, H. Drees, T. Geissler, M. Tarkiainen, P. Wadsworth, S. Schulz (2018), Implementation Aspects of C-ITS services with infrastructure involvement, Deliverable 2 of EU EIP sub-activity 4.4 (Cooperative ITS Services Deployment Support), https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/IntegratingC-ITS/EU%20EIP-44-D2-C-ITS%20Implementation%20Aspects-v1.0.pdf.

deployment perspectives has to take into account the technology evolution from ITS to CCAM and the sandwich position of C-ITS between the two. An example of the holistic view from the infrastructure point of view is provided by Riegelhuth[110].

From the infrastructure perspective, there is a well-established process via the C-Roads Platform how to enlarge the catalogue of C-ITS (Day 1 and Day 1.5) services incrementally, in a bottom-up coordination, resulting in harmonised specifications and communication profiles released twice a year[111]. This process comprises orientation in the short term and provides direction in the mid-term. It is also very useful to consult roadmaps of industry or industry-driven associations (e.g. Car2Car Communication Consortium, 5G Automotive Association, ERTRAC) which also serve as custodians of communication profiles. These roadmaps provide longer-term orientation about deployment plans referring to phased approaches[112,113,114]. Taking into account the organisation of the C-ITS pilots and deployment initiatives, there is a medium-term oriented development which is closely connected to the C-Roads platform. The C-Roads platform provides a catalogue of services and use cases which are specified, tested and verified. C-Roads encourages deployment of harmonised C-ITS services but does not put obligations on platform members to deploy particular services and use cases. The interoperability principle however requires when a service/use case will be deployed, it will be done in line with the agreed specifications and documents which accompany the C-Roads releases. It is expected that according to the agreed process of the deployment documentation (see the figure above) that the C-Roads catalogue will expand in the future along two dimensions:

- More C-ITS services will be verified. The verified services today match the list of Day 1 services (and Day 1.5 services)[115], in other words, the first C-ITS services with infrastructure involvement. These services provide information and warnings only. It is expected that services for Day 2 and beyond (Day 2+) will expand along the cooperation classes (SAE J 3216)[116] from status sharing over intent sharing to agreement seeking and prescriptive (actions). A near-term development into this direction would be a C-ITS service on automated vehicle guidance. When C-ITS services help fulfilling driving tasks beyond sensing, i.e. plan and act (see CCAM Platform WG 3 PDI matrix)[117] the issue of functional safety comes in and has to be tackled. The information on reliability, which is or could be a safety qualifier in terms of meeting functional safety requirements, would be an essential

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[110] Riegelhuth, G. (2020), The Strategy of Road Operators Considering C-ITS Day 2+ Services, Presentation to the Car2Car Forum 2020, November 2020.

[111] C-Roads (2021), Introduction to the C-Roads WG2 Deployment Documentation and Requirements, Version 2.0.0, and C-Roads Brochure, https://www.c-roads.eu/platform/about/news/News/entry/show/c-roads-brochure-available-for-download.html.

[112] Car2Car Communication Consortium (2021), Guidance for Day 2 and beyond roadmap, July 2021, https://www.car-2-car.org/fileadmin/documents/General_Documents/C2CCC_WP_2072_RoadmapDay2AndBeyond_V1.2.pdf .

[113] 5G Automotive Association (2020), A visionary roadmap for advanced driving use cases, connectivity technologies, and radio spectrum needs, September 2020, https://5gaa.org/news/the-new-c-v2x-roadmap-for-automotive-connectivity/.

[114] ERTRAC, Connected, Cooperative and Automated Mobility Roadmap, Draft for Public Consultation, Brussels 30.09.2021, https://www.ertrac.org/index.php?page=ertrac-roadmap

[115] European Commission (2016), A European Strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility, COM (2016) 766 final, Brussels 30.11.2016.

[116] SAE International (2021), Taxonomy and Definitions for Terms related to Cooperative Driving Automation for On-Road Motor Vehicles, SAE J 3216, July 2021, https://www.sae.org/standards/content/j3216_202107/.

[117] CCAM Platform, Final Report of the Single Platform for Open Road Testing and Pre-Deployment of Cooperative, Connected and Automated and Autonomous Mobility Platform (CCAM Platform), Brussels, July 2021, https://transport.ec.europa.eu/transport-themes/intelligent-transport-systems/cooperative-connected-and-automated-mobility-ccam_en.

element towards extending operational Design Domains of automated vehicles.
- Each C-ITS service will cover more and more use cases. The service will be deeper or richer in functional terms. For example, the road works warning service communicates amongst others lane closures. How long-term road works can be communicated, making use of or combine different message types, is discussed for quite some time in the community but has not evolved yet to a harmonised specification.

By nature, the C-Roads service catalogue has a short- to medium-term range towards the future. The timespan is predefined by the process of coming up with harmonised and tested specifications. From proposing new services and/or new use cases to harmonised specifications the perfect process (no delays in working out, much aligned views on how to provide the service) lasts one to one and a half years. The test cycle involving test protocols, exchanging PCAP (packet capture) files, verifying the interoperability adds on top so that this overall process requires two to three years of lee time.

Some more specific issues are related to the transition of pilot deployment to full-scale deployment and integration of C-ITS services into day-to-day operation. Processes have to put in place how to, e.g., implement changes to the specifications aligned across sectors (automotive-road infrastructure), how to solve problems, to provide a first line of help to users of C-ITS services, to monitor operations and to monitor performance of services etc. The C-Roads report on (the needs for) a fully operational ecosystem for C-ITS service delivery from the road infrastructure point of view (December 2021) lists the necessary processes and provides a perspective towards possible governance structures for multi-actor collaboration without a regulatory anchor (as the Delegated Regulation on C-ITS has proposed). There is also the need to align future platforms taking care of (but being not limited to it) the knowledge management and the deployment monitoring on ITS as well as C-ITS, on both motorways as well as urban roads. Figure 14.4 suggests this development with regard to lifecycle phases. While streamlining platforms is a valuable effort, it should be mentioned as a caveat that C-ITS operation requires taking on tasks of quite heterogeneous nature (e.g. change management, problem management, end user support). They correspond to the (bundled) roles and responsibilities which can be distinguished following ISO 17427-1[118] between system operation, functional operation, system management and policy framework.

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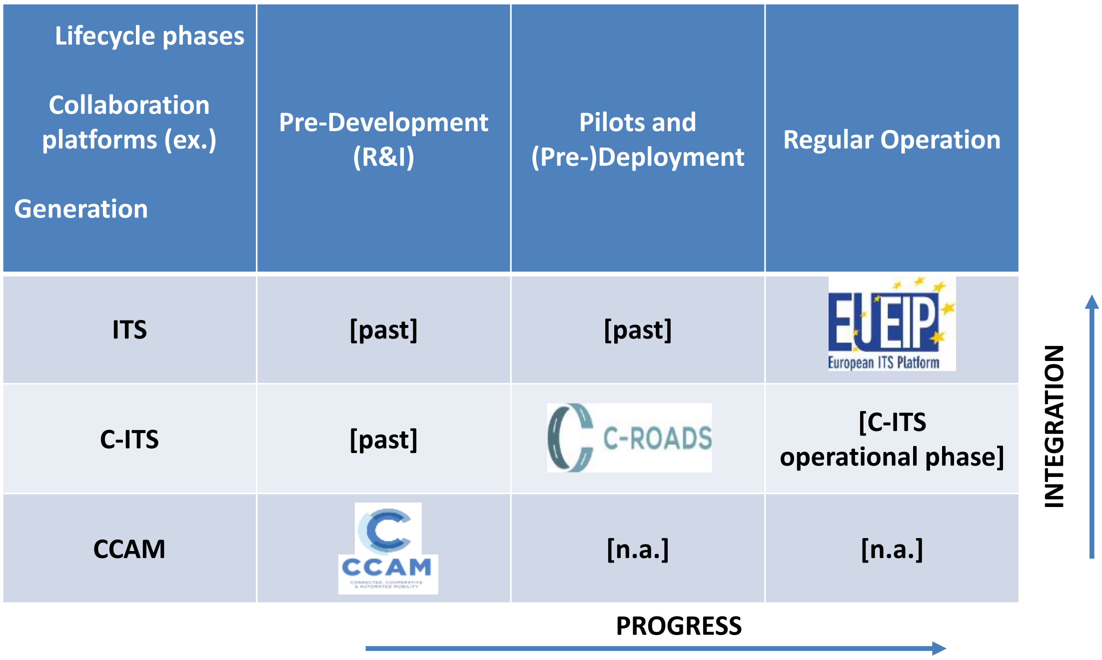
[118] ISO 17427-1, Intelligent transport systems — Cooperative ITS — Part 1: Roles and responsibilities in the context of co-operative ITS architecture(s), 2018, https://www.iso.org/standard/66924.html.



Lifecycle phases Collaboration platforms (ex.) Generation	Pre-Development (R&I)	Pilots and (Pre-)Deployment	Regular Operation
ITS	**[past]**	**[past]**	EU EIP European ITS Platform
C-ITS	**[past]**	C-ROADS	**[C-ITS operational phase]**
CCAM	CCAM	**[n.a.]**	**[n.a.]**

Figure 14.4: Collaboration for harmonised development and deployment

A longer-term element would lean towards and align with the industry-driven roadmaps, as argued above. It would envisage to extend the cooperative and collaborative capabilities on the way to CCAM services. It would also open up to fully embrace the possibilities and taking advantage of the in-vehicle data as provided by the Data for Road-Safety (DFRS) ecosystem[119]. Clearly, there is room for expansion, in more Member States or road operators joining the initiative, as well as more OEMs sharing their data. There is also room to extend the collaboration beyond the eight data categories of the Delegated Regulation on Safety-Related Traffic Information (SRTI). Obviously, this does not come for free but is a good step in finding the place (roles and responsibilities) in the wider CCAM ecosystem. Further, it goes without saying that road authorities and operators should also be open to the solutions that new technologies can provide (e.g. 5G enabled low latency services), to test them in the field and at their traffic management centres as well as to openly share the results and lessons learned and to deploy them. This all comes with the caveat that coexistence mechanisms between competing technologies have been proven for their workability (ETSI studies), so that previous investment in improving road safety, traffic efficiency and environmental friendliness is prevented from devaluation while also providing opportunities to enter the market for newcomers.

The future evolution of C-ITS services deployment is elaborated in the *Roadmap for C-ITS service implementation beyond initial deployment*. Based on this strategy from the viewpoint of a road authority, concise *recommendations for the continuation of C-ITS deployment* are given for the most important issues. Each recommendation can be mapped to the lifecycle of C-ITS deployment (horizontal axis in Figure 14.5). Most of them refer to the sandwich position of C-ITS deployment between ITS and CCAM (vertical axis). But also the interfaces to legacy ITS systems at the roads and in the traffic centres have to be considered as well as the transition to CCAM.

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[119] https://www.dataforroadsafety.eu

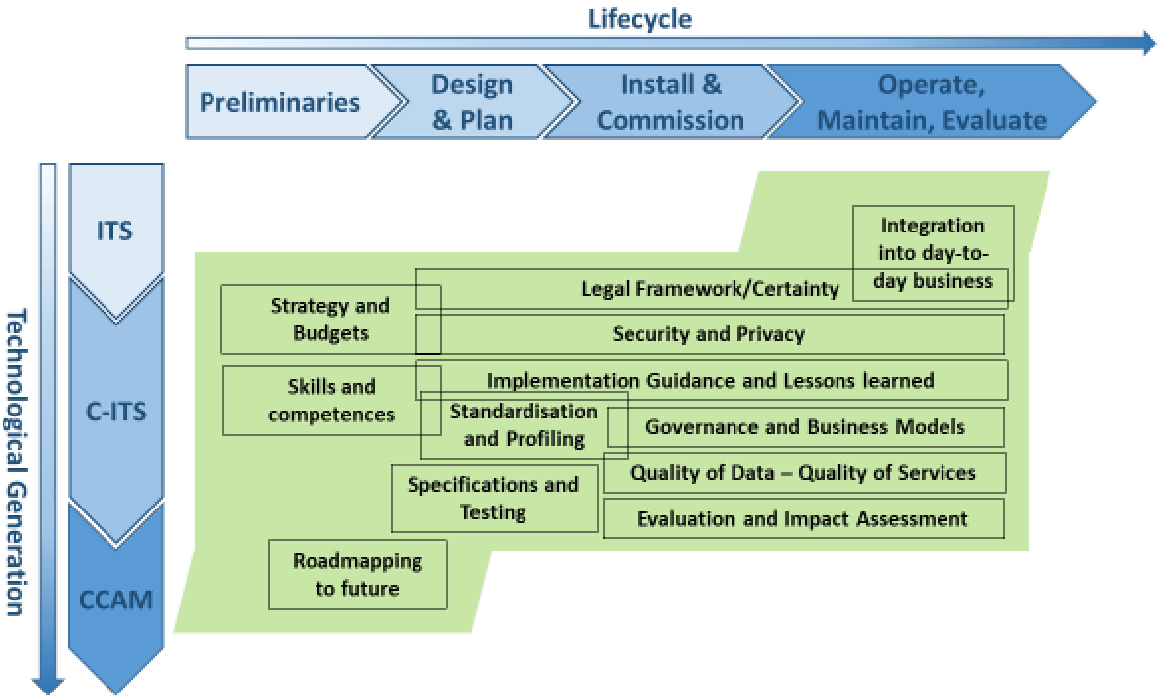

Figure 14.5: Recommendations for the continuation of C-ITS deployment

14.5 Outlook

In the course of the EU EIP project, the C-ITS landscape has evolved significantly. While the C-ITS activity of EU EIP was an important bridge builder, more powerful structures have been established in the meantime with the C-Roads Platform as the place where European road operators share their knowledge about C-ITS services and speak with one voice to the outside. Great harmonisation efforts have been undertaken which is continuously carried forward, also after the first C-Roads projects have ended.

Some contents of the presented deliverables will support and guide further road operators with the deployment of C-ITS services, some will have to be updated regularly with the latest evolutions. Most of the members of the EU EIP C-ITS sub-activity contribute to a C-Roads pilot or other C-ITS deployment initiatives and carry forward the heritage of this sub-activity.

Annex: List of abbreviations

4G	Fourth Generation mobile telecom standard
5G	Fifth Generation mobile telecom standard
802.11p	approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments
ACEA	European Automobile Manufacturers' Association
ADAS	Advanced Driver Assistance Systems
AID	Automated Incident Detection
ANPR	Automatic Number Plate Recognition
APIs	Application Programming Interfaces
Arc Atlantique	Arc Atlantique is an ITS corridor implemented by 7 Member States
ASECAP	European Association of Operators of Toll Road Infrastructures
AUTOMOTO	Automated Driving on Motorways project
AV	Automated Vehicle
CAD	Computer Aided Design
CBA	Cost Benefit Analysis
CCAM	Cooperative, connected and automated mobility
CCTV	Closed-circuit television
CEDR	Conference of European Directors of Roads
CEF	Connecting Europe Facility
CEN TS	Comité Européen de Normalisation Technical Specification
CID	Corridor Information Document
C-ITS	Cooperative ITS
CNCs	Multimodal Core Network Corridors
CO_2	Carbon dioxide
C-Roads	the platform of harmonised c-its deployment in Europe
Crocodile	ITS Corridor project in Central Europe
DATEX II	electronic language (standard) used in Europe for the exchange of traffic information and traffic data
DCAT-AP	core model for describing and exchanging descriptions of public sector datasets
DDT	Dynamic Driving Task
DLM	Dynamic Lane Management
DG CONNECT	Directorate-General for Communications Networks, Content and Technology
DG DIGIT	Directorate-General for Informatics
DG-MOVE	The Commission's Directorate-General for Mobility and Transport
DIVA	dynamic integrated traffic situation analysis

DRIP	Dynamic Route Information Panels (Dutch name for VMS)
DSRC	Dedicated short-range communications
EasyWay	Predecessor of the European ITS Platform (EU EIP)
EC	European Commission
ELF	European Location Framework
ERA	European union Agency for Railways
ERTICO	European Road Transport Telematics Implementation Coordination
ERTRAC	European Road Transport Research Advisory Council
ETSI	Sub-division of the European Standards Organization (ESO)
EU	European Union
EU EIP	European ITS Platform
EWC	East-West Corridor
GIS	geographic information system
GDF	Geographic Data Files
GNSS	Global Navigation Satellite System
GTFS	General Transit Feed Specification
GTFS-RT	General Transit Feed Specification Real Time data extension
HD	High-definition
HDV	Heavy Duty Vehicle see HGV
HGV	Heavy Goods Vehicle
HSR	Hard Shoulder Running
HW	Hardware
I2V	Infrastructure – Vehicle
ICT	information and communications technology
INEA	Innovation and Networks Executive Agency predecessor of INEA
INFRAMIX	EU project to prepare road infrastructure to support the coexistence of conventional and automated vehicles
INSPIRE	Infrastructure for Spatial Information in Europe
ISAD	Infrastructure Support for Automated Driving
ISO	International Organization for Standardization
ITPS	Intelligent Truck Parking Services
ITS	Intelligent Transport Systems
JRC/EULF	European Union Location Framework
KPIs	Key Performance indicators
LAR	Local Algorithmic Response
LIT	Leading Innovation Timeline
Lo-Lo	Lift-on/lift-off or LoLo ships are cargo ships with on-board cranes to load and unload cargo.

LOSAD	Level of Service for Automated Driving
MANTRA	EU Project on automated driving
MedTIS	Mediterranean corridor Deploying Traveller Information Services
MMTIS	MultiModal Travel Information Services
MS	Member State
MRM	Minimal Risk Manoeuvres
MSU	Motorway Signalling Units
NAP	National Access Point
napDCAT-AP	draft specification for Metadata in National Access Points (NAPs) in Europe
NAPCORE	National Access Point Coordination Organisation for Europe
NeTEx	Network Timetable Exchange (standard)
Next-ITS	European ITS corridor project covering the Northern part of the Scandinavian-Mediterranean corridor.
ODD	Operational Design Domain
OECD	Organisation for Economic Cooperation and Development
OEDR	Object and Event Detection and Response
OEM	Original Equipment Manufacturer
OJP	Open Journey Planning
PDI	Product Data Interchange
POLIS	Network of European cities and regions cooperating for innovative transport solutions
Power BI	Software for business intelligence
PSAP	Public Safety Answering Points
PSI	Public Sector Information
REST	Representational State Transfer
Ro-Ro	Roll-on/roll-off (*RORO* or ro-ro) ships are *cargo* ships designed to carry wheeled cargo
ROI	Return On Investment
ROSATTE	EU project on Road Safety Attributes Exchange Infrastructure in Europe
RTTI	Real-Time Traffic Information
SAE	Society of Automotive Engineers
S-curves	an "*S*"-shaped curve which serves a wide variety of compositional purposes
SIRI	Service Interface for Real-time Information in public transport (standard)
SLI+VSL	Speed Limit Information + Variable Speed Limits
SOAP	Simple Object Access Protocol (XML protocol)

SRTI	Safety-Related Traffic Information
SSTP	Safe and Secure Truck Parking
TAP	Telematics Applications for Passengers
TEN-T	Trans-European Transport Network
TERN	Trans-European Road Network
TIC	Traffic Information Centres
TISA	Traveller Information Services Association
TMC	Traffic Management Centres
TMP	Traffic Management Plan
TN-ITS	Transport network ITS Spatial Data Deployment Platform
TPEG	Transport Protocol Experts Group
TSI	Technical Specification for Interoperability
UITP	Union Internationale des Transports Publics
UNECE	The United Nations Economic Commission for Europe
UML	Unified Modelling Language
URSA MAJOR	The project URSA MAJOR neo aims to make goods traffic safer on European roads through the implementation of Intelligent Transport Systems (ITS).
V2I	Vehicle – Infrastructure
V2V	Vehicle – Vehicle
VMS	Variable Message Signs
VSL	Variable Speed limits
WAAR	Wide Area Algorithmic Response
WADL	Web Application Description Language
WG	Working Group
Wi-Fi	Wi-Fi is a family of wireless network protocols, based on the IEEE 802.11 family of standards
wifi-p	see IEEE 802.11p
XML	Extensible Markup Language
XSD	XSD (XML Schema Definition), a recommendation of the World Wide Web Consortium (W3C), specifies how to formally describe the elements in an Extensible Markup Language (XML) document. It can be used by programmers to verify each piece of item content in a document, to assure it adheres to the description of the element it is placed in

EUEIP

European ITS Platform