Nordic WAY 3

Recommendations for Interchange Network Deployment

NordicWay 3

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Nordic WAY 3

Document Information

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Abstract

The concept and solution of the Interchange (see §3.2) was developed in NordicWay to demonstrate the feasibility of using cellular communication technology between actors in the transport ecosystem, as a complement to the ITS-G5 short range communication technology previously proposed for C-ITS communication. The purpose of the Interchange is to enable exchange of real-time C-ITS messages over IP based cellular networks. The reason for the investigation of cellular technology is the geography of the Nordic countries with vast areas with low population density, especially Norway, Sweden, and Finland. The cellular technology has been demonstrated in several use cases in the project, using a communication message broker called the Interchange. The Interchange complies to the specifications developed by the C-Roads project. The Interchange supports federation over country borders and between instances of the Interchange. Two instances have been developed and deployed during phase 3 (NordicWay 3), one in Sweden and one in Norway. In addition, there is a third instance deployed in Sweden for performance testing purposes. They were developed by two independent development organizations. A third (fourth) instance is currently being deployed in Finland. This instance is based on the Norwegian open-source solution.

In this report, we have examined the question of what is required for the Interchange to remain in operation after the end of the project funding. Interviews and workshops with actors from both the public domain and the private domain have been conducted. We conclude that there is great value in providing and operating an Interchange network. The services that are enabled have both great socioeconomic value and great commercial value. Some prerequisites are required to provide this value. These are discussed below.

The geographical coverage of the Interchange Network needs to be large for the commercial actors, mainly OEMs, to be able to invest in service development based on Interchange communication. The smallest geographical network coverage requested is Europe.

The Interchanges in the network can be operated by different types of organizations, but it is requested that these organizations are neutral and can be trusted having a long-term plan of operating the Interchange. It means that it is undesirable to end up in a commercial monopoly situation, where the Interchange operator can specify commercial terms without competition. Today there is no clear position in the Nordic countries on how to operate an Interchange.

There is no obvious commercial business model for an Interchange. However, it still needs to be financed. The actors interviewed in the scope of this report state that they are willing to share and pay the prime production costs for developing and operating an Interchange. There are several other studies external to this project ongoing regarding financing models of data markets in Europe, and this study does not recommend any specific model. We have noted that in countries where there exists a data exchange system for C-ITS data and services, these data exchanges are always publicly funded and operated.

One aspect where we have not been able to come to a clear conclusion is civil security. If operating C-ITS services through an Interchange, it is not unlikely that an outage in the operation of the Interchange might lead to disturbances in the traffic flow. This could make the Interchange a target for cyber security threats. This topic needs further investigation. It indicates that setting up an Interchange might have to be a national responsibility, since civil security is a national concern and responsibility.

In conclusion, the NordicWay project has demonstrated the ability of the technology and has set up an Interchange network for the exchange of real-time C-ITS messages, that is now operational. This network can be integrated in a larger network of Interchanges on European level, based on the C-Roads specifications. It remains to find the long-term solution to the operation responsibility of these Interchanges.

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Content

Definitions

C-ITS	Cooperative Intelligent Transport Systems
DATEX 2	Standard for exchange of traffic related data
EVA	Emergency Vehicle Alert
Interchange	Interchange is a data sharing concept that enables sharing of data and services through cellular networks
Interchange network	The Interchange network constitutes the core for cloud-to-cloud communication between vehicles and infrastructure
Interchange ecosystem	The Interchange network plus all actors interacting with the network
IVS	In Vehicle Signage
NAP	National Access Point
NIS2	Network and Information Systems, referring to the Directive (EU) 2022/2555
ITS-G5	Shortrange ITS communication based on WIFI standard 802.11.
On-Board Units (OBU)	Device installed in a vehicle that collects driving and traffic information and can communicate with infrastructure or other vehicles OBUs.
OEM	Original Equipment Manufacturer (vehicle industry)
RWW	Road Works Warning
V2G and V2H	Vehicle-to-Grid and Vehicle-to-Home

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1 Introduction

1.1 Background

Most countries struggle with challenges in the transport system such as CO2 emissions, high load on the road infrastructure, fatalities, and injuries. To solve those problems infrastructure has traditionally been built by adding new infrastructure, rather than improving existing infrastructure and, by extension, its' outcomes. Digitalization could enable communication between infrastructure, vehicles and other road users using Cooperative Intelligent Transport Systems (C-ITS). C-ITS services will play an important role to overcome those existing challenges, without extending the physical road infrastructure. Based on this, many different initiatives have emerged to explore the advantages that digitalization could bring; the NordicWay project is an example of such an initiative.

NordicWay was initiated in 2015 with the aim to test and demonstrate the interoperability of cellular C-ITS services. In NordicWay the Interchange network constitutes the core for cloud-to-cloud communication between vehicles and infrastructure.

One of the main objectives of NordicWay is to contribute to harmonisation and interoperability of C-ITS in Europe. After the completion of the first NordicWay project, the project was followed up by NordicWay 2, where focus was on pilot deployment of day 1 and 1.5 C-ITS services, see further section 3.1. The NordicWay 3 project has actively contributed to the work performed in the C-Roads Platform. The contribution has mainly been concentrated on the discussion regarding IP based communications.

If the focus within the earlier NordicWay projects has been on technical solutions for architecture and C-ITS-services, the NordicWay 3 project address the question of full-scale deployment.

1.2 Purpose of the Report

Within the NordicWay 3 project a large focus is placed on the Interchange, the different flagship pilots and the Proof-of-Concept tests ensuring the technical baseline for future C-ITS services. However, a focus that is purely technical can restrict these solutions from reaching their full potential in becoming implemented and commercialized services.

By widening the scope of the NordicWay consortium and project by solving adhering questions (such as for example, consolidation towards EU-standards, policy issues, business models, different roles and responsibilities in the future transport ecosystem) the next steps can be taken both for the Interchange and for the proposed demonstrations.

Therefore, workshops and knowledge exchange with the actors within the NordicWay 3 consortium have been carried out throughout the project on the above-mentioned topics.

This report aims at putting the achievements of NordicWay 3 into an international perspective and investigating and proposing necessary further actions to fully scale up and make the NordicWay 3 results available and commercially used in full scale. Priority is placed on future deployment and business models for C-ITS services.

1.3 Structure of the Report

Chapter 2 of the report includes a description of the various methods that have been used to gather and process data in this project. Thereafter, findings are presented in three separate chapters (chapters 3,4 and 5) with different characteristics. Chapter 3 *Cooperative Intelligent Transport System and Interchange Ecosystem* – describes the fundamental aspects that need to be understood when investigating deployment models for an Interchange Ecosystem. Chapter 4 – *International Perspective and* – gives a sample of initiatives within the field of C-ITS. It also gives an account for the updated ITS directive. In chapter 5 – *Results and analysis* – results divided into a set of themes from interviews and workshops are presented. Conclusions from all types of findings and results are discussed in chapter 6 – *Reflections and Conclusions*. The report ends

with chapter 7 – *Recommendations* – which contains ten recommendations about how to work with the Interchange going forward.

2 Method and Work Conducted

Several methods have been used to gather and process data in this project. What methods have been used, based upon literature, interviews, and workshops, and when they have been applied in the process can be seen in Figure 1. Schematic view of conducted work. Throughout the project, reoccurring meetings with the NordicWay 3 steering group have been held. The methods are described in further detail in this chapter.

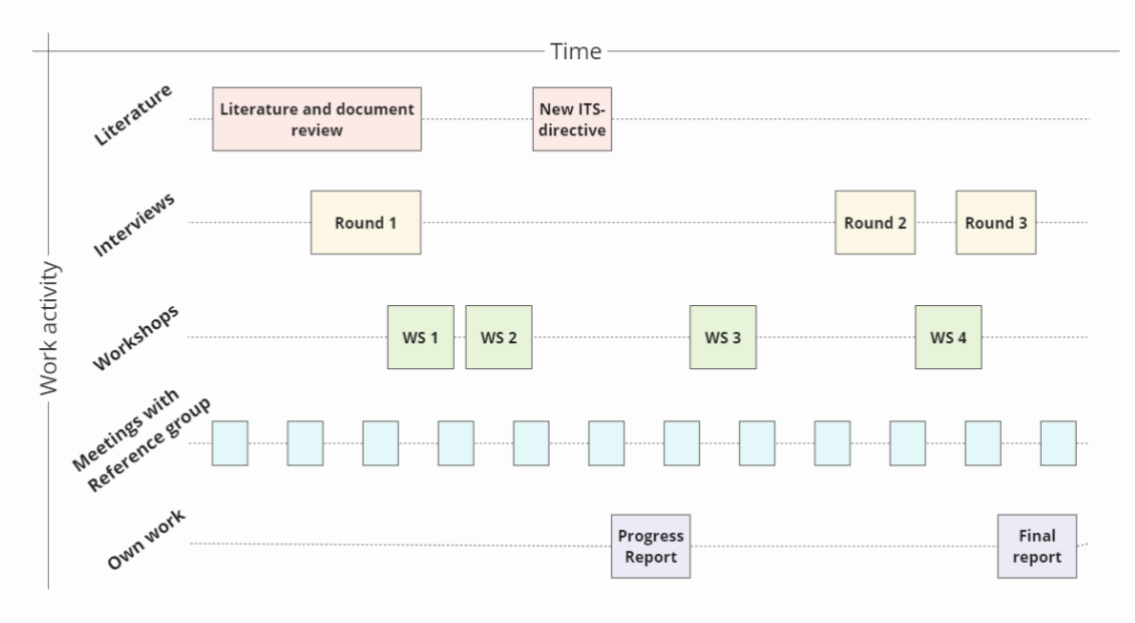


Figure 1. Schematic view of conducted work

The methods in the project are based on a simplified version of the research strategy called *Grounded Theory*, see Figure 2. Grounded theory is a well-known methodology which is used in qualitative studies. New theories can be formulated by collecting closely related data from real-world settings and analysing data from participant observations and interviews. This method is iterative and collects a substantial amount of data. The grounded theory process allows for a structured approach to data analysis.

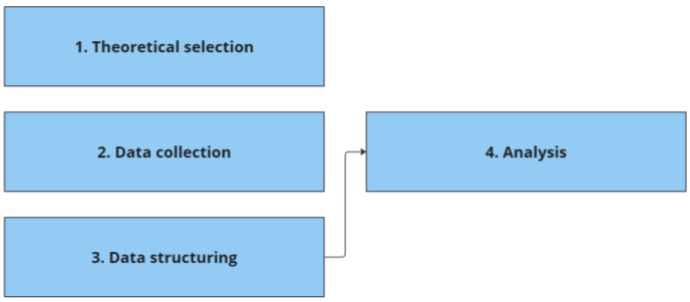
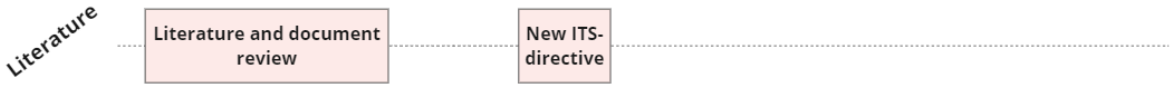


Figure 2. Schematic overview of the simplified version of Grounded Theory.

The first three steps were carried through ahead of the progress report (which is described in the following section), after which the main focus was directed towards analysing the results from the different concluded steps of the project.

2.1 Literature and Documents Review



The literature review focused on data sharing initiatives, EU standards and policies. There is great interest in the area and there are many initiatives at many levels, resulting in a fragmented view of the subject. The results of the literature review are mainly found in chapters 3 and .4.

To further develop the understanding of the proposal for the update of ITS Directive 2010/40/EU and its ramifications, a thorough reading of it was carried out within the project team. This was conducted as a structured group reading exercise to not miss out any nuances or details of the changes and updates of the ITS Directive. All the members of the group read the updated ITS Directive and then discussed their thoughts and reflections together. In section 4.1, the findings from the reading exercise are presented.

2.2 Interviews

An interview guide was developed based on Business Model Canvas which is a strategic management template that can be used for understanding and developing business models. Questions were formulized within the themes *Value proposition, Partners & Influence, Customers & Payment, Key resources, Costs* and *Trends & Future*. The guide was adjusted somewhat based on the role of the person interviewed.

Three rounds of interviews were conducted. During the working process, extra rounds of interviews were added due to the introduction of new questions about topics that had not been addressed in the first phase.

An anonymized list containing all the 37 interviewees can be found in the appendix. Interviewees represented a range of organizations that work with or are affected by the development of C-ITS. Both public and private organizations were interviewed. Most of the interviewed organizations are part of the NordicWay project. The Swedish, Norwegian, Danish, and Finnish transport administrations and the Swedish government office are examples of represented public authorities. From the private sector, interviewees from OEMs, software manufacturers and consultancy firms were among the respondents.

The initial round of interviews consisted of 16 interviews with interviewees recommended by the NordicWay 3 steering group, national coordinators and activity leads within the NordicWay 3 project. All of them were involved in different activities within the NordicWay 3 project with the majority of them representing transport administrations from the aforementioned countries. Some of the potential interviewees could not participate and were put on a rest list that was intended to be returned to later in the project. However, input from workshops and other external events meant that the rest list was not thought to be relevant at later stages. The data from the first round of interviews formed the foundation of the continued work together with insights from the literature and document review. The interview results were structured in a workshop described in section 2.3.1.

The project team concluded that the private sector's perspectives were required following the fourth workshop that was held during the NordicWay 3 conference in Finland. Therefore, a second round of interviews was initiated with OEMs and other private actors providing services related to the Interchange. Questions regarding data, risk and security, deployment and funding of the Interchange and communication protocols were asked.

Findings from the nine interviews that were conducted in the second round were clustered before the fourth workshop (section 2.3.4), in which they were processed further.

The project team concluded later in the project that there was a knowledge gap regarding the theme security. For this reason, two additional interviews were conducted, which made up the third round of interviews. Data from these interviews made the completion of sections 5.6 to 5.8 possible.

Through all the rounds of interviews, the reference group has assisted in identifying and contacting interviewees relevant for the work package.

2.3 Workshops

The process has included four workshops. The authors of this report have both led and participated in workshops. In some cases, they have included members of the larger NordicWay 3 consortium and in other cases have been held in the smaller project team.

2.3.1 WS 1. Internal Workshop and Data Structuring

After the first round of interviews, a workshop was held within the project team, with the interview data as input. The workshop was performed in accordance with the simplified version of the Grounded Theory. Coding was done statement by statement to create conceptual themes in an iterative process where each statement was processed several times which enable evaluation and refinement of the themes.

Table 1. Themes from data structuring

Main theme	Sub-theme	Summary statement
Governance	Policies and legal framework Standardization International harmonization	“The governance framework for the interchange node is yet not in place.”
Business model	Public ownership Private ownership Unclear ownership	”A platform for data exchange is necessary but no one wants to take the responsibility.”
Reliability	Trust Cyber security	”The framework for trust and cyber security is unclear.”
Technical solution	Interchange node Cellular vs short range, Applications Evaluation	”Large focus on technical solution without convergence.”

Sweden	National coordination Organization Other technical solutions	”Swedish positions are diverging.”
Positions (deployment model)	Next step NordicWay Sweden Norway Denmark Finland Netherlands	”The progress in the Nordic countries differs (from each other).”
Impacts	Autonomous drive Safety Distribution Traffic system Usability Environment	”Where are the impacts, especially regarding sustainability?”

2.3.2 WS 2 Prioritizing Workshop at NordicWay 3 Conference

The second workshop was held at the NordicWay 3 conference in Gothenburg in April 2022. The conference had 150 attendees that all participated in different activities in the NordicWay 3 project. All conference attendees were invited to partake in the workshop out of which about 40 persons participated. This group of 40 was divided into two separate workshop sessions in which four themes were processed:

- Governance
- Positions
- Business model
- Impacts

The selection was made based on what the project team believed to have the strongest connection to the objective of this study. For each of the four themes approximately 10 summarized statements from the interviews were presented to the participants in the workshop. Note that the word *interchange node* was replaced with *Interchange* later in the project. For example:

- “The governance framework for the interchange node is yet not in place.”
- “A likely prerequisite for C-ITS services to exist is that there is a publicly funded platform for exchange of data.”
- “Municipalities do not have the resources to be responsible for and finance data exchange.”
- “It’s not likely to succeed with this if private actors have to pay for interchange node from the beginning.”
- “New business models are needed for sharing data, but no business models for private actors to provide an interchange node are found.”
- “The absolute most important is that it is a clarity about what will happen with Interchange node after NordicWay 3. Otherwise, the development of services will stagnate.”

- "We can't reward individual companies' solutions and we must not exclude future technologies in our regulations. At the same time, the digitalization requires similar technical solutions/functionalities from the contractors."

These statements were first briefly discussed from a validation perspective, i.e. Do you agree? Is it correct? In a second step, the statement was analysed through a "Complexity - Strategic impact analysis", where a four-fielder was used (example below) representing strategic impact on the x-axes and level of complexity to solve on the y-axis.

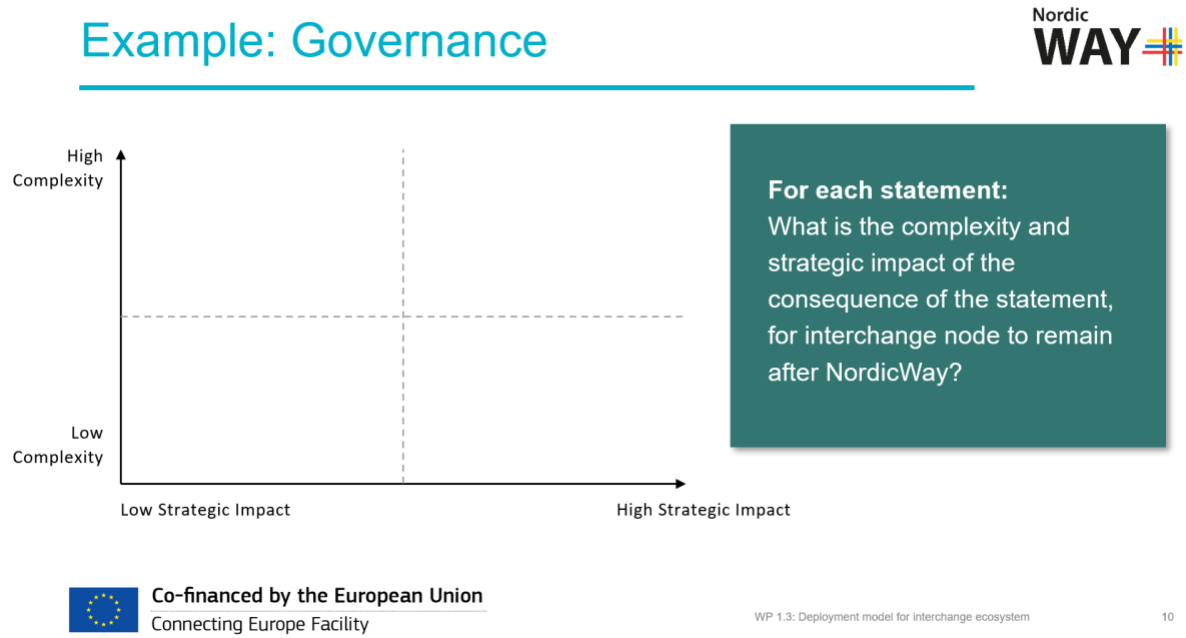


Figure 3. Four-fielder used at the Prioritizing workshop, NordicWay 3 conference.

2.3.3 WS 3 SWOT Analysis

Based on the themes developed in WS1 after the first round of interviews and in WS2 during the NW3 meeting in Gothenburg, the next phase of the project focused on the transport administrations (TA) of the four countries Sweden, Norway, Denmark, and Finland. The chosen method for this was SWOT (Strengths, Weaknesses, Opportunities and Threats). The aim was to explore the views of the TAs on the financing models. Based on the assumption that there would be one Interchange in each country, the topics were set to be 1) initial funding for development, and 2) cost of ownership, of the Interchange. Initial funding was proposed to be:

- Public funding
- Private funding
- Joint (public + private) funding, as in NordicWay in Sweden with in-kind financing

There were then four models of ownership (including the financing of the ownership) proposed:

- Publicly owned
- Privately owned
- Jointly owned
- Open source (in practice no owner, as in the case of Norway)

This gives 12 possible combinations. Based on likelihood and practice, four of the combinations were selected:

1. Public initial funding + Public ownership

2. Private initial funding + Private ownership
3. Joint initial funding + Private ownership
4. Joint initial funding + Open source

WS3 was conducted as four separate workshops, one with each country's Traffic Administration. For each of these workshops, the TAs had to work with all four cases above, leading to four SWOTs from each of the four workshops.

The results are summarized in section 5.4.

2.3.4 WS 4 Developing Themes from the Second Round of Interviews

A fourth internal workshop was held after the second round of interviews had taken place. Firstly, the results from the interviews were processed into statements within a set of clusters as part of the interview method. Thereafter, the project team conducted a fifth workshop that aimed to identify themes from the data from the second round of interviews. The second interview round had focused on private actors and generated themes about how Interchange services should be priced, who should be responsible for its operation and other aspects that were deemed important by the interviewees. The result from workshop four is incorporated in chapter 5 and played an important part in collecting data for segments about potential business and deployment models. Main themes can be seen in Table 2 below.

Table 2 - Main themes identified in workshop 4.

Price	Operation	Other aspects
Free of charge (publicly funded)	Private actor operates Interchange	Big market
Cost price	Neutral actor operates Interchange	How to get started
Commercial price		Interchange brings social benefits

2.4 Reference Group Meetings

A reference group consisting of representatives from the Norwegian, Swedish, and Finnish Transport Authorities has been assisting the progress throughout the project. Meetings have been held monthly in which ideas and concepts have been exchanged and identified themes have been discussed, and thereby confirming or rejecting preliminary conclusions from the project team. The steering group has, as previously mentioned, provided contacts to interviewees relevant for the different phases of the process.

2.5 Own Work

Writing the so-called progress report was a step in processing the data that had been gathered throughout the first half of the project. This action was deemed essential for communication, both internally within the project team and externally toward the steering group and other relevant actors. Lastly, a final report that built upon the progress report and new data was written.

3 Cooperative Intelligent Transport System and Interchange Ecosystem

Cooperative Intelligent Transport Systems (C-ITS) is the use of wireless technology that facilitates communication between vehicles and infrastructure. This communication enables real-time exchange of information between different road users, road network managers and service providers, improving coordination, safety, and efficiency on the roads. This chapter includes a description of the different deployment phases of C-ITS services, a review of how the Interchange Network functions and a list of collaborating actors that will be required for a successful deployment of C-ITS services,

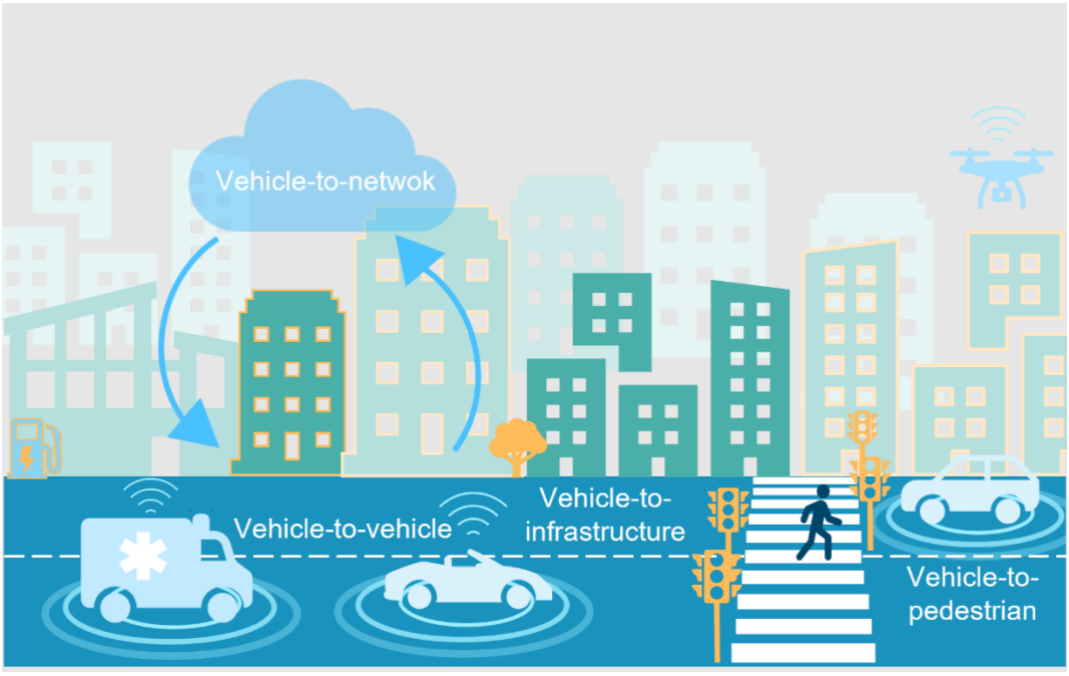


Figure 4. Intelligent connecting the car to cloud and surroundings through cellular communication.

This report will only address vehicle-to-network.

3.1 Deployment of C-ITS Services

The level of technical maturity of the C-ITS service was originally divided into three deployment phases called “days”. Generally, the first day of C-ITS development is about delivering information and warnings to vehicles about for instance traffic jams or road works ahead. The second day includes sensing driving, where vehicles collect data with information and warnings from different types of signals and traffic situations. In the day 3+, vehicle-to-vehicle and infrastructure-to-vehicle communication enable cooperative automated driving. Examples of C-ITS services in the different phases are presented in Figure 5.

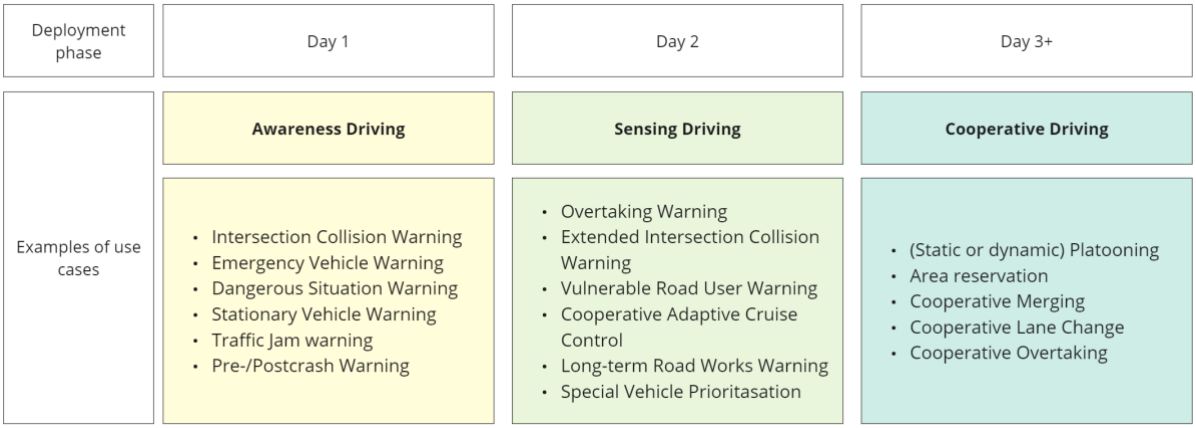


Figure 5. Examples of C-ITS services divided into phases based on deployment phase (CAR 2 CAR Communication Consortium, n.d.).

There is also a fourth phase, day 1,5. The deployment of day 1,5 services haven't reached the level of deployment of day 1 services yet but are generally more commonly available compared to day 2 and 3 services.

Continuity and availability of C-ITS services across EU for end-users are seen as the most important factors for deployment of C-ITS in Europe. The European Commission[1] considers that a list of technologically mature C-ITS services should be deployed rapidly to generate benefits for end-users and society as soon as possible. These early deployment services, day 1 and day 1,5 C-ITS services, and are listed below in Figure 6.

[1] European Commission (2016), A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected, and automated mobility. COM/2016/0766

Deployment phase	Day 1		Day 1,5
C-ITS services	**Hazardous location notifications:**	• Slow or stationary vehicle(s) & traffic ahead warning • Road works warning • Weather conditions • Emergency brake light • Emergency vehicle approaching • Railway crossing • Unprotected accident area • Obstacle on the road • Reduced visibility • Traffic jam ahead warning • Other hazards. • Traffic information and smart routing	**Generelly mature but not ready for deployment 2019:** • Information on fuelling & charging stations for alternative fuel vehicles • Vulnerable road user protection • On street parking management & information • Off street parking information • Park & ride information • Connected & cooperative navigation into and out of the city (first and last mile, parking, route advice, coordinated traffic lights) • Cooperative collision risk warning • Loading zone management • Motorcycle approaching indication
	Signage applications:	• In-vehicle signage • In-vehicle speed limits • Signal violation / intersection safety • Traffic signal priority request by designated vehicles • Green light optimal speed advisory • Time to green • Probe vehicle data • Alert wrong way driving • Shockwave damping (falls under European Telecommunication Standards Institute (ETSI) category 'local hazard warning').	
	Zone access:	• Dynamic environmental zones • Dynamic access control of designated infrastructure	

Figure 6. Day 1- and 1,5 C-ITS services stated listed as prioritized by European Commission (2016).

A collaboration platform named C-Roads was initiated by eight EU member states, but it is open for other member states as well. Today there are 19 core member states that agree to work together to achieve deployments that give travellers interoperable and seamless C-ITS services across European borders. The initiative behind the C-Roads platform was taken to ensure that the member states and road operators can test and implement C-ITS services to achieve cross-border harmonization and interoperability[2]. Most of the listed Day 1 C-ITS services in Figure 6 are a part of the C-Roads platform and piloted in one or several European countries[3].

3.2 Interchange Network and Ecosystem

The Interchange is a concept implementing a protocol on top of the bearing communication technology. The specifications of an Interchange are developed with the aim of being compatible with the European specifications for C-ITS developed in C-Roads.

The Interchange is a data sharing concept that enables sharing of data and services. The Interchange can be seen as a message broker. Service providers can request from the Interchange what data they are interested in, for example traffic accidents. The Interchange finds the information and creates a data stream that fits those criteria available to the service provider. The service provider creates services based on the data and provides these services to users that subscribe to requested information, through the Interchange. Each Interchange keeps track of all the datasets that are available from the data providers.

Two communication technologies are utilized within the C-Roads platform: ITS-G5 and Cellular (eventually 5G)'. The standardized C-Roads protocol enables vehicles and infrastructure to communicate via C-ITS messages in real time. Real time aspects have been evaluated and

[2] The C-Roads Platform – An overview of harmonized C-ITS deployment in Europe. C-Roads (2021). (C-Roads Brochure 2021)

[3] The following day 1-services are in the focus of the C-Roads platform. C-Roads (n.a.). (Implemented Services: C-Roads)

tested within NordicWay 2 for the use cases developed within NordicWay 2, but not for other more advanced use cases like autonomous driving.

The term “the Interchange" may sound like it refers to just one node, but it often refers to multiple nodes. In fact, there can be several different Interchange implementations that are able to communicate with each other to provide seamless communication between users or actors. For the purposes of this study, in this report, Interchange is considered a general concept that can be implemented as one Interchange or many.

The ecosystem consists of these main actors, the relations between these pictured in Figure 7:

- Data producers
- Service Providers
- The Interchange and its operation
- Data (and service) consumers

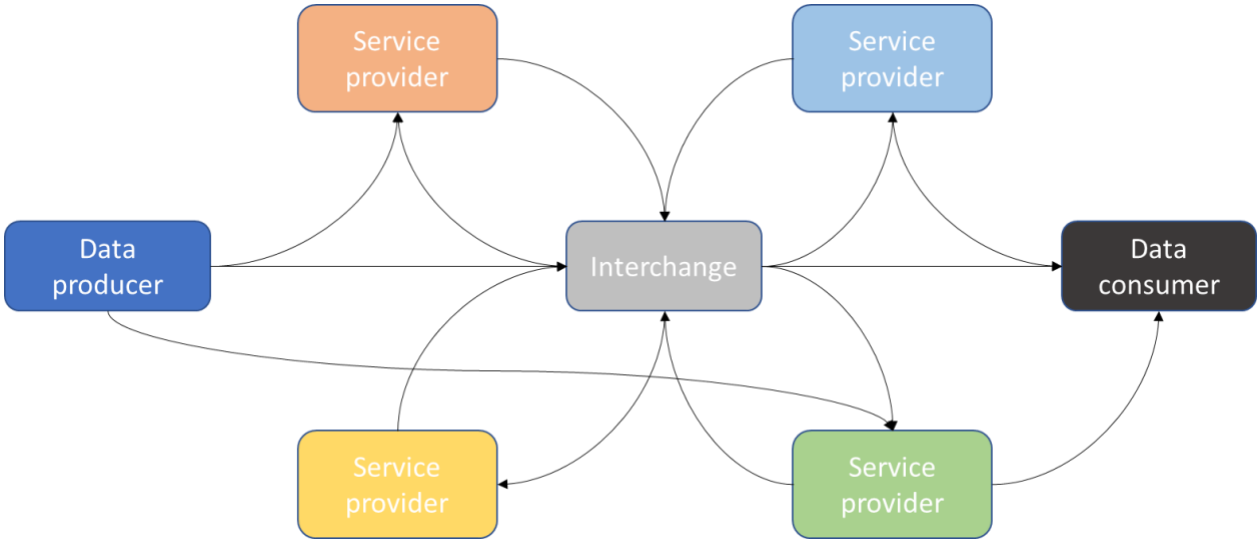


Figure 7. Schematic view of the Interchange and its main actors.

The service providers have different operation modes, depicted by the different colours.

- Service is created solely via information available through the Interchange, and published solely through the Interchange (yellow)
- Service is created both using information available through the Interchange and other available data, and published solely on the Interchange (orange)
- Service is created solely via information available through the Interchange, and published both on the Interchange and directly to data consumer (light blue)
- Service is created both using information available through the Interchange and other available data, and published both on the Interchange and directly to data consumer (green)

An organization can take on the role of producer as well as consumer, but the roles are often performed in different business processes. Example of organizations:

- Road users
- Road operators
- Road authorities
- OEMs
- Maintenance entrepreneurs
- Mobility providers

- Municipalities
- Weather institutes
- Research institutes and organizations
- Parking operators
- Position data providers

3.3 Collaboration and roles

Harmonization and deployment activities of C-ITS across Europe, are done by authorities and road operators which are joined together through the e.g., C-Roads platform.

According to the C-Roads organization[4], it is expected that public budget will be allocated for the provision of C-ITS services that are transport information related and road safety related. Furthermore, it is expected that public actors will have responsibility for investments, maintenance and operation costs related to equipment for transport infrastructure. Private sector, on the other hand, is expected to provide market driven C-ITS solutions. Several collaborating actors will be required for a successful deployment of C-ITS services, some of them listed in Table 3 below.

Table 3. Roles of collaborating actors[5]

Actor	Role
European Commission	The European Commission is acting as the facilitator in both the research and deployment in the field of C-ITS services. A European strategy on Cooperative Intelligent Transport system has been adopted by the Commission to ensure coordinated deployment of C-ITS services in the member states. This strategy addresses questions as convergence of investments, regulatory framework, international cooperation, coordination, harmonization, and security certificates.
Public authorities	Public authorities are defined as any government or other public administration at national, regional, or local level. According to C-Roads, public authorities will be responsible for setting policies, establishing rules and regulations on safety, security, and environmental provisions. This will probably have a vital impact of the overall C-ITS system. Furthermore, they may assume responsibility of operating and maintaining a security infrastructure.
Road operators	The road operators have responsibility to contribute to policy goals along their road network. They have an important role regarding provisioning and consuming data.
Mobile network operators	For a successful deployment of C-ITS, cellular network for transmission of information between infrastructure and vehicles will be necessary. Mobile network operators are crucial for provision of such infrastructure.

[4] C-Roads (2022), Ecosystem for fully operational C-ITS service delivery.

[5] Report on Legal and Organisational Structure for C-ITS Operation, C-Roads 2018. (Report_on_legal_structures_for_C-_ITS_operation_v1_Final.pdf (c-roads.eu))

OEM	OEMs in the vehicle industry have a role in equipping vehicles with on board units that enables communication with roadside unit or a central unit.
Service providers and operators	Service providers are supplying services to customers, including other organisations or end users. The responsibilities of the service providers may differ, depending on type of provider. Typically, there is two types: Service providers communicating via apps or On-Board Units.

4 International Perspective and Outlook

Several initiatives related to C-ITS services have been identified in the literature and document review as well as in interviews and workshops. The chapter begins with a description of the updated ITS Directive, after which an outlook with a sample of relevant initiatives is presented.

4.1 ITS Directive

The new ITS Directive, or more specifically, the amendments of ITS Directive 2010/40/EU, have a significant impact on the deployment of Intelligent Transport Systems within the European Union (EU). The amendment aims to accelerate and increase the deployment and operational use of ITS services across the EU and to improve road safety, promote a multimodal transport system, increase interoperability and continuity of services, establish coordination mechanisms between ITS actors, and improve access to data. These goals also contribute to the main priorities for the transport system outlined in the strategy for sustainable and smart mobility: Greening and digitalization of the EU transport sector [6]. An increase in ITS services is expected to bring more requests of new services by users. Simultaneously, new ITS-services will demand further development of techniques, communication, and more.

The amended ITS-Directive also regulates sharing of significant data within the ITS area and will demand that data is shared within the ITS-system. This mandates data sharing while not specifying the compensation arrangements or the standards to be used.

Since the amended ITS Directive includes several updates, changes and additions of articles, an impact assessment was done when the amendment of the ITS Directive 2010/40/EU was conducted. The executive summary of the impact assessment[7] includes a comprehensive description and assessment of the initiative's added value and its links with other policy initiatives.

The summary of the impact assessment presents three policy options. The options differ in the level of ambition and the scope of intervention, with policy option 3 being preferred by the Commission due to its effectiveness and ability to generate net benefits. It is also deemed to best achieve the specific objectives of the ITS Directive and ensure a swift and coherent deployment of ITS services. Policy option 3 aims to mandate the provision of essential ITS services, such as real-time traffic information, multimodal travel information, eCall, and intelligent speed assistance. It also aims to further support the deployment of interoperable and continuous services, particularly those focused on road safety, such as cooperative intelligent transport systems and automated driving.

The implementation of the ITS Directive involves costs, investments, and benefits. Congestion and traffic jams result in substantial economic losses for the EU, and the expected benefit of policy option 3 is estimated at EUR 179.1 billion between 2021-2040. For maximum efficiency and benefits, the deployment of ITS must be done simultaneously throughout the EU. However, there are no penalties specified for member states that are unable to fulfil the deployment timetables.

The responsibility for implementing the directive lies with the governments of each member state, with progress reports to be submitted every 3 years. The creation of National Access Points (NAPs) is a crucial component of the directive, ensuring a single point of access to data. However, the ITS Directive does not mandate that the NAPs must be developed concurrently or that they operate in the same manner in each member state which means that the development and implementation of each NAP must be done through close cooperation between the member states[8].

[6] The European Green Deal – COM(2019) 640 final

[7] Commission staff working document executive summary of the impact assessment swd(2021) 475 final https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2021:0475:FIN:EN:PDF

[8] European Commission (N.D.), National Access Points

In conclusion, the new ITS Directive brings about significant changes and updates to enhance the deployment and use of ITS services in the EU. It addresses road safety, promotes multimodal transport, emphasizes data sharing, and relies on collaboration between member states for effective implementation. The directive aims to achieve a connected and automated multimodal mobility system, contribute to sustainable transport, and generate substantial economic benefits for the EU.

The 8th of June 2023, a preliminary decision was reached in the EU regarding the ITS Directive update. It now remains to be approved by the EU parliament[9].

4.2 Outlook of Initiatives Creating C-ITS Ecosystems

A list of initiatives dealing with data and communication that are important to consider when studying C-ITS is provided in Table 4 below. Some of the initiatives presented are interrelated. For instance, the Gaia-X as well as two of its lighthouse initiatives Catena-X and Mobility Space are listed in the table.

Table 4.Summary of initiatives relevant for the studies of C-ITS

Initiative	Description
C-Roads	C-Roads is a platform that aims to harmonize C-ITS related deployments throughout Europe. Through the C-Roads Platform, authorities and road operators coordinate the deployment of C-ITS across Europe. The objective is to provide interoperable cross-border C-ITS services to road users. Common technical C-ITS specifications, including the common communication profiles, are developed, shared and published[10]. The C-Roads Platform is directed by the Steering Committee, which is made up of representatives from Member States of the European Union.
NAPCORE (National Access Point Coordination Organization for Europe)	The NAP, defined by the European Union in Directive 2010/40/EU, is a mandatory implementation for each member state. The requirements for the NAP are not precise but most countries have chosen to implement it as a metadata platform. The NAP provides information about how to find traffic-related data but does not share the actual data. As a result, there is no standardized protocol for accessing data, and real-time availability differs for the different data producers [11]. The NAP is governed by the NAPCORE (National Access Point Coordination Organization for Europe) organization[12].
Gaia-X	Gaia-X is an initiative initiated by *Europe for Europe and beyond*, comprising over 350 members from business, politics, and science. The purpose is to create a federated and secure data infrastructure where data and services are available, collected and shared. Gaia-X develops

[9] Council of the EU and the European Council (2023). https://www.consilium.europa.eu/en/press/press-releases/2023/06/08/council-and-parliament-strike-a-deal-on-the-roll-out-of-intelligent-transport-systems/

[10] C-Roads (2022), Ecosystem for fully operational C-ITS service delivery.

[11] European Commission (N.D.), National Access Points

[12] UITP (N.D.) NAPCORE: Moving Europe forward with data

	policies, rules, technical frameworks, and regulatory frameworks to achieve this goal. The infrastructure is designed to be deployed on top of existing cloud platforms, allowing companies and citizens to collate and share data while retaining control over their data and data sovereignty[13]. Gaia-X also establishes hubs in member states to connect potential stakeholders within and across countries and sectors. By 2021, 16 Gaia-X hubs had been established, including representation from the Nordic countries Sweden and Finland [14]. The project has received strong support from the German and French governments and maintains close links with the European Commission. The Swedish hub is particularly active, recognizing the importance of Gaia-X for Sweden and its data economy business ecosystem[15]. Gaia-X covers four core elements: *Federation Services*, *Standards*, *Business Services*, and *Data Spaces*. *Federation Services* defines the technical requirements and services for operating the Gaia-X ecosystem. An architecture of *Standards* is developed by aligning and describing existing standards, facilitating interconnectedness within Gaia-X. *Business Services* establish common rules for collaboration, minimizing challenges and enabling new services and innovations. *Data Spaces* refers to the data relationships between trusted partners within Gaia-X, where data is stored at the source rather than centrally. Gaia-X spans various domains, encompassing data spaces in different areas such as Energy and Mobility, allowing providers to participate in multiple data spaces simultaneously [16].
Catena-X	One of the seven lighthouse initiatives that make up the Gaia-X association is Catena-X. Its main objective is to make it easier for the automotive industry to automate business processes and exchange data by creating a uniform standard for data exchange throughout the entire automotive value chain. The International Data Spaces (IDS) guidelines for data sovereignty must be followed by all Catena-X consortium members[17]. The project has 63 industry participants, including Mercedes-Benz, BMW, Deutsche Telekom, Siemens AG, and Robert Bosch, and is supported by government funding[18].
Mobility Data Space	Mobility Data Space is another Gaia-X lighthouse project aiming to facilitate Gaia-X-compliant data exchange. Its key goal is to enable competition around innovative, environmentally sustainable, and user-friendly mobility. The project utilizes a decentralized system architecture known as IDSA (International Data Spaces Association). Mobility Data Space provides access to real-time traffic data and sensitive mobility data, integrating data from the public and private sectors via regional and national platforms. Data providers have control over the conditions

[13] Gaia-X (N.D.) What is Gaia-X?
[14] Gaia-X (2021) Gaia-X Hubs – Join a thriving network across Europe.
[15] Gaia-X (N.D.) Why join?

[16] Gaia-X (N.D.) Core elements

[17] IDS (2021-03-03) Catena-X: Network for cross-company data exchange in the automotive industry relies on IDS.

[18] International Data Spaces Association (2022) The IDS approach for cross-sectorial sovereign data sharing as enabler for extended supply chains: a dive-in into the automotive domain

	under which their data can be used by third parties, ensuring data origin and quality traceability for billing and payment purposes[19]. The Mobility Data Marketplace (MDM) is the German NAP[20] and a platform that incorporates some of the concepts from the Mobility Data Space[21]. It contains searchable metadata accessible via the web, although it is not machine searchable. Access to metadata search is free, but data providers and users must register as MDM users. Transactions within the MDM are logged; however, it is currently not implemented in an IDS-compliant manner. MDM, which serves as the central point for road traffic data in Germany, was established as part of a German government initiative.
European Mobility Data Space	The European Mobility Data Space aims to facilitate access to and reuse of mobility data, involving all relevant stakeholders. It is not a data space built on a single platform but based on platform and ecosystem exchange and interoperability. The creation of an architecture, common design principles, building blocks, and tools to support the convergence of governance and infrastructure is supported by the European Commission. The data space is built on two main pillars: existing and developing EU frameworks that govern data sharing and reuse, as well as European initiatives, data ecosystems, platforms, and marketplaces driven by member states or private actors[22]. The project PrePDSpace4Mobilitty aims to lay the foundation for the common European Mobility Data Space and is set to hold its final workshop in September 2023[23].
Road Infrastructure Safety Management Directive	To improve the road safety in member states of the European Union, the Directive on road infrastructure safety management (RISM) was adopted in 2008. The legal framework provided by the directive had the aim to harmonize legislations to a common standard among the member states. In 2019 the Commission extended the scope of the original directive to the main national road network.
Car 2 Car Consortium	The Car 2 Car Communication Consortium (C2C-CC) is a non-commercial consortium established in 2002 by vehicle manufacturers with the goal of improving road safety through foresighted driving[24]. The consortium focuses on cooperative Vehicle-to-Everything (V2X) communications, particularly Infrastructure-to-Vehicle (I2V) communication. Car2X applications utilize the local ad-hoc wireless short-range communication standard ETSI ITS-G5 and subsequent radio standards. In a cooperative road traffic scenario, ITS stations are implemented in vehicles and traffic infrastructure to exchange data via

[19] Mobility Data Space (N.D.) Mobility Data Space – Sovereign Mobility Data Ecosystem

[20] National Access Points – A mechanism for accessing, exchanging and reusing transport related data – under Delegated Acts of the ITS Directive (2010/40/EU)

[21] Mobility Data Space (N.D.) The MDM in the Mobility Data Space.

[22] European Commission. (2021). Report – Workshop on the common European mobility data space. European Commission.

[23] PrepDSpace4Mobility. About the project. (2023-08-31). https://mobilitydataspace-csa.eu/

[24] C2C AboutUs.pdf, dated 2021-10-27.

	the V2X short-range ad-hoc network. These units communicate information such as position, speed, driving direction, and event-triggered messages about incidents. Roadside units in the infrastructure provide information on traffic lights, speed limits, and road works. The Car 2 Car Communication Consortium has standardized and harmonized the data elements and formats of these messages to enable cross-border communication among vehicles from different manufacturers, ensuring privacy through regular pseudonym changes and tamper-proofing messages through signing.
Data for Road Safety	Data for Road Safety, initiated in 2017 by European Transport Ministers, the European Commission, and industry partners (including OEMs), aims to significantly improve road safety across Europe for all road users[25]. Originally named the European Data Task Force, the initiative involves the active participation of vehicle manufacturers, traffic information service providers, automotive suppliers, and public authorities. The core principles of the Data Task Force are: working together to make driving safer, prioritizing safety without compromising and sharing data across brands and borders and fostering a fair and trusted partnership between government and industry stakeholders. The Safety Related Traffic Information (SRTI) Ecosystem was established to facilitate the exchange of data and information within a trusted domain. Partners within the ecosystem agree to exchange data free of charge for the sole purpose of road safety, based on the principle of reciprocity, and strictly for creating Safety Related Traffic Information, with no permitted commercial use cases.
Connected, Cooperative & Automated Mobility (CCAM)	The goal of the CCAM Association is to create a more user-centred and inclusive mobility system, increasing road safety while reducing congestion and environmental footprint. By bringing all the relevant stakeholders from diverse sectors such as industry, research, services, public and local authorities, associations, SMEs, the CCAM Association aims to accelerate the development of new technologies and their deployment in real life with all that implicate; Road safety and efficiency, Inclusiveness for everyone, Impacting beneficially the environment and answering the Climate Change challenges society is facing, Make Europe the centre of CCAM technologies
TN-ITS	TN-ITS is concerned with information exchange on changes in static road attributes. Road safety and efficiency require highly updated digital maps for ITS, but map providers struggle to keep these elements current. The solution is to retrieve the information on changes from the road authorities. As regulators of these changes, e.g., speed limits, they are the most immediate and reliable source for such information. TN-ITS's vision is that TN-ITS provides the updates on trusted, authoritative, and regulatory road data to support ITS applications such as Safety, Automation and Efficient Mobility, and that TN-ITS is a mandatory exchange format in the EU Mobility Data Space. TN-ITS contributes to the NAPCORE project by providing its knowledge and expertise in road data sharing through the specification and further

[25] Data for Road Safety. (2023). Data for Road Safety. Retrieved from Ecosystem (Background): https://www.dataforroadsafety.eu/ecosystem#background

elaboration of the TN-ITS standard. NAPCORE has taken one step further in data standards harmonization, by the signing of the Declaration of Lisbon 2023 during the ITS European Congress, initiating the merging of TN-ITS and DATEX II standards.

5 Results and analysis

In this chapter the results of the activities that has been performed during the work, as described in chapter 2, is presented. The chapter is divided in a set of themes that early in the project were identified as key aspects to consider for a successful deployment of an Interchange Network.

5.1 Governance

One of the main findings within the theme is that the governance framework for the Interchange network across Europe is not yet in place. The digitalization might require reorganization of road authorities, but most importantly, the road authorities must address road network development and management in a different way, considering the needs and possibilities that digitalization brings. Responsibility for IT-infrastructure, standardizations and cyber security will be required within the organizations of road authorities.

The Interchange network makes it possible to build a complete ecosystem across borders and scale up the network into endlessness. Interviewees agree with the purpose of NordicWay 3; that it is important that all Nordic countries can agree and align on a solution within the project to influence Europe and in a longer perspective reach a harmonization across EU.

A harmonization of data sets and data provision creates a complete ecosystem across borders which would facilitate the integration for OEMs and data sources. New standards for communication with traceability are needed to maintain a safe channel for communication and with an Interchange this is feasible, say interviewees. This is done by C-Roads, and potential future organizations for C-ITS harmonization at EU-level. Nordic road authorities' continuous participation is important to prioritize and secure.

Regarding security and integrity, C-ITS messages must follow the security and certificate policy stated by European parliament. The European C-ITS trust model is based on Public Key Infrastructure (PKI) within the scope of the overall EU C-ITS Credential Management System (EU CCMS). This policy is binding for all entities participating in the trusted C-ITS system in Europe.[26]

Interviewed actors also express difficulties to reach national harmonization. The regions and municipalities (e.g., in Sweden) are autonomous which might lead to a variation of digital solutions in the road transport system. The procurements must be regulated to a greater extent to achieve harmonization, say interviewees. At the same time as the digitalization requires similar technical solutions/functionalities from the entrepreneurs; it is not possible for authorities to reward individual companies' solutions. Nor can they exclude future technologies in the regulations. National regulation through the transport authorities and transport agencies are probably necessary to achieve similarity and interoperability in the road network owned by different road operators. National regulation needs certainly to be aligned with EU and global regulation when such regulations exist. Furthermore, there is a need to govern the standards in a deployed C-ITS ecosystem.

Netherlands is mentioned as a successful example of coordinating towards national harmonization. They have a legal framework in place and a national data coordination authority for an active coordination between authorities, regions, and municipalities, called Nationaal Dataportaal Wegverkeer[27].

5.2 Coordination and Organization

Several interviewees raise the question about harmonization across the whole road network, as mentioned earlier. All municipalities do not have the resources to share traffic related data, such

[26] Annex 3 to the Commission Delegated Regulation supplementing Directive 2010/40/EU – C(2019) 1789 Final

[27] NDW is a National Road Traffic Data Portal

as road works warnings (RWW), emergency vehicle alert (EVA) and geofencing zones. Interviewees express the need to have one authority that is responsible for such data in the transport system and by that secures availability.

Besides national coordination, there will be a need to clarify responsibility for the it-infrastructure, responsibility for standardization, and responsibility for cyber security. These responsibilities could be handled within the current organizational structure or if needed in new organizational structures. Respondents also mention that the traditional work at the transport administrations must be reconsidered when implementing C-ITS services and for sharing data. They need to work more in parallel across the organization, where the people who work with the questions practically needs to be involved to a greater extent.

Some of the transport administrations have other implemented or planned data platform solutions which either complement or overlap the functions of the Interchange. Other discussed solutions during interviews are the NAP, DATEX2 and the Swedish transport administration's upcoming Data exchange platform (Datautbytesplattformen). An interviewee from an OEM wishes that the data in the NAP would be available directly through the Interchange. Other interviewed representants argue that today's arrangement with a metadata base platform is preferable.

However, it is not clear how the different technical solutions should exist together in the future transport system and the transport administrations are urged to make a choice about the future of the Interchanges and organize the governance before deployment. Here, the EU-initiative European Mobility Data Space (see chapter 4) also could be key to bring clarity.

5.3 Standpoints of National Public Road Authorities on Organization and Governance

The Nordic countries have agreed to technical aspects of the Interchange network but have taken different positions to the governance of it. The progress of this governance is varying in the different countries.

The Swedish Transport Administration states that they only should provide the data from their own sources. They also give the impression that they will not take responsibility and finance an Interchange network. The Swedish Transport Administration is currently working on the project Datautbytesplattformen, which translates as " the Data Exchange Platform". The aim of this project is to create a data exchange dedicated to public data, excluding private data.

The Swedish Interchange for NordicWay is built by the Dutch company Monotch. However, what will happen after the NordicWay project is unclear. The transport administration in Denmark is on another hand clear; they will build, maintain, and fund their Interchange outside the NordicWay project. Denmark have not built an Interchange within NordicWay, but the future solution will align with the Interchange network solution.

The response from Norway and Finland is a bit more difficult to interpret. Norway develops and operates the Interchange inhouse at the Norwegian road administration to build the knowledge within the organization. Some interviewees consider that there could be another alternative solution being preferred after NordicWay, while others report that Norwegian Transport Administration will have a public Interchange as a part of their infrastructure. However, in Norway the Interchange is developed under open-source license which makes it possible for commercial actors to build competing or complementary Interchange solutions. Interviewees from Finland say that Finland has a firm commitment to the Interchange network. In the last progress meeting of NordicWay, it was reported that Finland has started to develop an Interchange based on the Norwegian open-source licence.

The Netherlands could be seen as a forerunner in the development of a data exchange ecosystem, since they seem to be the only European country with a data exchange platform similar to the Interchange in operation, however not compatible and cannot be connected to the Interchange network. In the Netherlands they also have a legal framework in place, as well as a

national data coordination agency with the purpose to coordinate municipalities, regions, and authorities.

The different standpoints, or lack of standpoints, creates confusion and disturbance among the actors, especially actors from the private sector. According to the interviewees, clarity about what will happen with the Interchange network after NordicWay 3 is crucial. Otherwise, the development of services will stagnate.

5.4 Business Model

The main part of the responders does not have a clear picture of how the Interchange will be owned and financed. An obvious finding is that a platform for data exchange is necessary but that no one feels main responsible for the development, operation, and maintenance of the Interchange.

Already in the first workshop, several participants were sure to point out that the Interchange must be seen as a system of several nodes, and that it's a concept that enables efficient sharing of data across national borders. An actor has previously tested to build one Interchange for several countries, but there were issues with the funding, procurement, and ownership of such a solution. Their opinion is that it's easier to have at least one Interchange per country. Other respondents say that they believe that there most probably will be numerous Interchanges in each country. This also opens the possibility for having different business models for the different Interchanges.

Looking at the Dutch Urban Data Access Platform as an example, that platform is financed by the public sector. Further the willingness to own and finance the Interchange differ between the Nordic Road authorities. Some of the interviewees explain that the Interchange could be the platform/channel for the road authorities to share their own data. Other responders claim that public funds will be necessary for an Interchange to exist, at least in the beginning. One actor argues that the Interchange will be too important for the road operators, road authorities and public sector to just give away the control of to the private sector.

Mainly interviewees from the road authorities mean that the private sector should finance and be responsible for the Interchanges, mostly because of the interest from OEMs to use the data and services. Suggestions are given on a business model based on subscriptions from users, OEMs and mapping and navigation services. One interviewee from the private sector explains that users/OEMs are willing to pay for some services/applications where they as individuals/companies can benefit. But some services mainly create societal benefit, and therefore the user's willingness to pay is small.

Several of the respondents mentioned that the cost for operating and maintaining the Interchange is relatively low, yet it has not been established who is willing to pay for it. Interviewees from the road authorities claim that the public sector shall not intrude where there is a viable private business sector that can offer solutions. However, an interviewee reminds of the cause of Finland's lack of an Interchange; the companies building it couldn't see the long-term business model for it. This could indicate that there is a need for the public sector to take the lead and become the catalyst to create or accelerate the market. However, creating a market that doesn't exist by itself does not always lead to a good result.

One of the interviewed actors summarizes the challenge of business models very well, *"It isn't the technology or the protocols that are difficult to agree on, it's the setup of the business of how to use the information".*

There are certainly several possible approaches to the funding and ownership of the Interchange. Four of them were selected; Public funding and ownership, Private funding and ownership, Joint funding and private ownership, Public initial funding and open source. Those four were discussed more in detail in workshops with national road authorities, where a summary of the pros and cons for different setups can be seen in the table below.

Yet, no explicit positions have been stated, but so far it´s clear that the road authorities in the Nordic countries have different strategies regarding the Interchange network after the end of the NordicWay project.

Norway has decided to continue to fund the maintenance of the open-source Interchange network after the end of NordicWay 3. Denmark is aiming to combine the NAP concept with C-ITS real time data sharing according to Interchange network architecture/functionality. Sweden is investing in their own data sharing platform, and there seem to be no Interchange network concept in their strategy. Finland was not aiming for an implementation of Interchange at the time of the workshop.

However, recently in Finland a NordicWay 3 project activity has been performed about how C-ITS services should be implemented in Finland, and to identify actors and their roles in the implementation of the C-ITS services and the infrastructure required by the services. Related to this study there is also a Finnish Interchange pilot, where an Interchange is developed utilizing the Norwegian open-source code. The purpose of this pilot is among other things also to establish a permanent Interchange for future needs managed by Fintraffic. An Interchange solution intended to be active also after the end of the NordicWay 3 project.

To complement the workshops held with the national road authorities, an additional round of interviews was performed focused mainly on the private sector’s view on the Interchange.

An Interchange that is entirely funded by the public, thus being free of charge for users was preferred by some of the interviewees. One argument for this arrangement was that the digital infrastructure should be seen as part of the physical structure.

One private actor mentioned that they were willing to pay the prime cost price for the Interchange but added that a price on commercial basis could make the Interchange self-funding. Such a solution could then become an incentive for private actors to build and operate the Interchange.

Regarding operation of the Interchange, one actor thought that having a private operator would be positive in terms of developing the service. Others mentioned that a neutral operator would ensure reliability and avoid a private monopoly which could risk unequal conditions for users.

Many of the interviewees agreed that it is of importance to have a widespread market for the services related to the Interchange to be able to reach many customers and to motivate private actors to create and implement services. Generic solutions and widespread definitions of how data should be used are vital for the private actors.

How to get started was another subject discussed by several interviewees. Some believed that public authorities need to be the driving force in implementing the Interchange and C-ITS in general. Others mentioned that Sweden now lack a leading organisation. If not getting started, societal benefits such as increased traffic safety would be missed.

Table 5. Pros and cons of different types of funding and ownership, identified in workshops with national road authorities in Denmark, Finland, Norway, and Sweden.

	+	−
Public funding and ownership	Neutral Focus on societal benefits Support more use cases Less dependent on business model Complete control	Hard to get funding Budget priority can vary over time Slow technical development Not connected to the needs of the industry
Private funding and ownership	High innovative ability Focus on market needs Competition to accelerate development No public money needed	Continuity depends on revenues Business model unknown Hard for services with societal benefits to exist without revenues Limited control over critical infrastructure Risk for monopoly Harder to get harmonization
Joint funding and private ownership	Serve both public and private interests Less need for public funding Lower investment risk for commercial actors Easier for newcomers to enter the market	Risk for vendor lock in and unequal competition in the market Legal obstacles for the public actor to finance a private company Non-interest of private companies to finance, one part drops out
Public initial funding and open source	Improved development and growing ecosystem Less need for public funding New actors could be easily involved The public body will maintain access to the system Avoid vendor lock-in	Lack of knowledge about what open-source means Uncertain role for public actor e.g., regarding security needs Lack of interest of private sector to develop the Interchange further How to ensure equal treatment of service providers etc?

5.5 Technical Solution

There is a large focus on *technical solutions* within NordicWay 3. Based on interviews and workshop, it is clear that there is an agreement that the Interchange is a suitable technical solution for distribution of real time traffic data through cellular communication. Short range communication using ITS-G5 has been the main focus in the first C-ITS deployments in Europe, however for Nordic countries this is not a sustainable solution for their large road network with relatively low traffic volumes. Through NordicWay the Nordic countries were able to prove that cellular communication is feasible and functional according to requirements of the tested services for real time traffic information.

Several interviewees point out that a big advantage of the Interchange network is that it is an easily scalable solution which could be used in several countries together, and also be implemented in different ways in different countries. It is seen as a new standard for how communication between public authorities and OEMs and other private companies will be performed in the future, instead of communication between roadside units and vehicles. The Interchange network is also described as an enabler since the market won't be able to share data across OEMs as it seems today, based on a strong historical culture and competition legislation not to communicate with competitors.

Some interviewees mean that the qualities of the Interchange network are necessary for some C-ITS services, such as geofencing, to exist. The data exchange is event-driven, and the latency is low. The protocol solution is also suitable for exchange between companies' servers in an organized way (instead of individual units), which provides the cyber security that is requested, one OEM explains. Other advantages with the Interchange are described, such as the possibility to subscribe to certain data on the platform.

Further, there seem to be different opinions about which kind of data the Interchange is suitable for. One interviewee says that the Interchange is not an adequate channel for sharing vehicle data such as friction. The architecture is more suitable for small messages, rather than large data sets.

5.6 Reliability

The reliability of both the Interchange network and the data is of highest importance for the ITS-services to succeed. The source of the data also needs to be reliable, that means that all data which is shared on the Interchange network must be verified from several aspects, e.g., data supplier, accuracy, personal integrity, security, etc. The demands on security can be read in section 5.7 below.

Several interviewees point out that the vehicle safety is crucial, and that the vehicles cannot be dependent on connection to servers for a safe driving. This is however of highest importance when it comes to autonomous driving. The services that are provided today are advanced driver assistance support, and under these services the driver has the full responsible for driving the vehicle. The risks with data sharing are expected to be similar for commercial actors as well as for public actors.

Interviewees highlight that the most important aspect is to achieve trust that the information is traceable, even if the information is refined. There must be a way to verify the authenticity and sender of the data, claim interviewees. Interviewees further say that it is relevant to think about how data and senders should be certified within the Interchange network, and which criteria there should be. One respondent claims that the ITS policy and the updated ITS-directive gives a good framework for assuring quality. Interviewees also presume that it is more likely that the vehicles act on the information if it originates from a public authority.

The interviewed OEMs explain that an internal development work will be required for them to be able to achieve and handle the data in a safe way in the C-ITS services. They will also be required to review the implementation several times to be able to trust it. When they can verify the quality, they can trust the data and use it in their services.

Several interviewees also raised the driver's perspective and the question about *usability*. One concern is about harmonization in the road network where there are different road authorities. The traffic safety will benefit if the driver gets the same information on the whole road network. It could also be a distraction if the driver does not get expected information on a road section on municipal roads.

Interviewees also address the importance that they can rely on a long-time commitment to keep an Interchange working.

5.7 Security

This section is about security and personal integrity and our findings from literature and interviews. This aspect was added later in the process as there was a lack of input on this topic in earlier work. The input is still limited, but some important questions have been identified. We couldn't find that the overall strategic issues regarding national security have been considered in NordicWay 3, which leaves questions about that subject unanswered.

Cyber security has a wide definition and is pointed out as an important, but complex, factor within digitalization of the road transport system. Cyber security is strongly linked to national and international sections of laws within areas such as national security, information and network security, privacy, and personal data[28]. Within the topic of Cyber security, GDPR was also brought up as a subject for discussion during interviews. There is a fear and insecurity about how to handle new regulations among actors when they are implemented.

Interviewees confirm that handling data through an Interchange raises questions about security aspects and personal integrity. And that countries, companies, and organizations IT-systems are under constant attacks.

Who can own this kind of infrastructure? There have been examples from the Nordic countries with people on sanction lists owning companies or sport arenas. How can we ensure that that won't be an issue for this infrastructure solution, that an Interchange is owned by a sanctioned organization or person?

GDPR raises the question about personal integrity, how can data be exchanged via Interchange without compromising personal integrity?

How can we be prepared so that it will be as hard as possible to disrupt a future Interchange and thereby all services provided via the Interchange?

An interviewee says that the Swedish Transport Administration is more experienced in working with physical infrastructure. Cyber security aspects are becoming more and more important. In Sweden the cyber domain is added to the earlier domains (land, air etc.) as a domain for the national defence. It's important to protect our ability, and the security aspects are a big challenge. There should be government control if it's classified as important. The responsibilities of the state and authorities should however be at a level which makes it possible for innovations from other parts of society. Aspects linked to security are becoming more important. More strict legal requirements are expected in the future, and it's important to have that in mind while setting up solutions.

The opinions reflected above from the interviewees were common regardless of if the interviewee was working with ITS-services, collecting data, data sharing, OEM developing or data communication. These opinions also follow the focus area of cybersecurity that the European Parliament is regulating to protect citizens in Europe.

The continuous development and implementation of C-ITS can be seen as a step towards autonomous vehicles and transport. In 2017 the European parliament adopted a new resolution, Civil law rules on robotics (2015/2103(INL)), also including smart transports.

[28] FOI (2019), Cyber security regulation for smart traffic.

One focus area in the resolution is on responsibility and damages and this shows a future regulation of smart robotics. The resolution defines a smart robot as a physical system that can gather information through sensors or connection to a network. The system can also learn from information about their interactions and experiences.

The resolution states that cybersecurity aspects not only include autonomous vehicles, but also the infrastructure that the vehicles use for communication.

The project NordicWay 3 doesn't cover autonomous vehicles, but NordicWay 3 is a step in that direction. This should be taken into consideration during the development of the Interchange network so that the requirement in the regulation is fulfilled when the Interchange network is deployed.

This regulation within the European union shows how important cybersecurity is, and that information and data that are communicated within the transport sector has to be seen as sensitive and needs to be protected. Data which is shared without control may be in breach of GDPR.

The former Article 29 Working Party, now replaced by European Data Protection Board, highlighted in an opinion a risk with peer-to-peer communication in C-ITS services. This type of communication makes it easier to spread information and thereby more difficult to protect [29]. However, the Working Party also noted that a security solution for this type of communication is the use of PKI. Unfortunately, it has been more common in the recent past that certifications are given to users only for the purpose of performing harmful acts.

The state must have an organisation for governance, regardless of deployment model. There are security aspects that needs state supervision.

5.8 Impacts

The interchange is an enabler, and the exchange of data is needed for many of the C-ITS services to work, and for some to work better. The impacts on society are relevant when seeking a suitable business model for the Interchange. The impacts of an interchange could further be divided into two categories; impacts as a result of the services which are developed and dependent on an interchange, and impacts that are a direct consequence of the Interchange.

The largest benefit of the Interchange is that it makes it possible to share and receive real time traffic information in a federated way, says one interviewee. Several other interviewees point out that the Interchange will be an important asset to enable autonomous driving in the future. The literature study also implicated that there are numerous other possible areas of use where the Interchange can contribute. Especially in areas that today operate in silos, but which need to be linked together to accelerate the conversion. As an example, digitalization is described as a tool to accelerate the progress of the ongoing electrification of the transport sector. Electrification can further be seen as an interconnection between energy infrastructure and transport infrastructure, where digital infrastructure interconnects the two. When it comes to integrating the electric vehicle with the electric grid or the real estate, the concept V2G (vehicle-to-grid) and V2H (vehicle-to-home) can be used. V2G and V2H will play an important role when it comes to bridging existing barriers. For example, if a booking system of charging infrastructure is requested, where digital solutions and communication will be necessary to calculate time of arrival, charging needs, time to departure etc. Platforms for data exchange will be essential for these kinds of executions [30].

The services implemented and piloted within NordicWay 3 are chosen based on their degree of maturity, not according to the grade of societal impact. Further, the effects of the piloted services

[29] Opinion 03/2017 on Processing personal data in the context of Cooperative Intelligent Transport System (C-ITS) 17/EN WP 252

[30] VTI (2022), Regeringsuppdrag om elektrifiering av transporter – Digitaliseringens möjligheter att effektivisera och påskynda elektrifieringen av transporter – inklusive rättsliga förutsättningar.

are mostly related to safety aspects like reduced number of accidents. The piloted services will also have a positive effect on queues, and furthermore on emissions[31]. Impacts of NordicWay 3 related C-ITS services, according to interviewees, are shown in Table 6.

Table 6. Some examples of effects of studied C-ITS-services and their distribution over the country according to interviewees.

Service	Effect	Geographical distribution
EVA (Emergency Vehicle Alert)	Positive effect on the risk for accidents with emergency vehicles and better accessibility for emergency vehicles.	Roads with high traffic flows
Geofence bearing capacity	More efficient cargo transports. More efficient use of infrastructure.	Probably rural areas
RWW (Road Works Warning)	Positive effects regarding safety and progress for maintaining entrepreneurs. Follow-up of road works.	Roads with high traffic flows
Traffic Signal Priority	Increased accessibility for public transport and emergency vehicles.	Cities
Traffic signal Information	Effects will be studied; they may be both positive and negative. May increase efficiency.	Cities
In Vehicle Signage	Effects will be studied	All roads

As shown in the table, the effects may be unequally distributed geographically. In the cities where the traffic volume is large, the contribution will be higher for a certain sort of services. There is a risk that there will be solutions which will function well in big cities but not for the rural areas, due to lack of data from too few cars. The conclusion from earlier work within NordicWay 2 Activity 2[32] is that benefits would outweigh the costs but mainly on the roads with high traffic volumes.

Several interviewees also mentioned that C-ITS is becoming a well-known concept, but that it isn't clear if the broader public understands their benefits of the services, and if there is a willingness to pay for them. The conclusion from NordicWay 2 is that the willingness to pay for the solution (for most citizens) is probably going to be low. At that time the concept was never heard about 54-66% of people and only 3-6% hawing used them themselves. If C-ITS services make the car transports more attractive than the alternatives, the traffic volumes will increase. However, C-ITS services have benefits regarding public transport, heavy traffic and might replace investments in physical infrastructure as well, and the total effects are not clear.

5.9 Socioeconomic Impact

Socioeconomic impact can be both positive and negative and is closely linked with the earlier section 5.8 about impacts. The socioeconomic benefits are best evaluated comparing cost for investments and costs of maintaining operability to effects both positive and negative for the society. The timing when investments and effects occur is important to know if the impact assessments are to be reliable.

The differences in cost between no Interchange and several Interchanges with different ownerships is an important part of the evaluation. The costs of implementing and yearly

[31] NordicWay 2 – Evaluation results Version 1.0, 16 December 2020

[32] NordicWay2 (2020) Evaluation results

maintenance will differ between different solutions. Cost can also vary in the aspects of controlling regulatory compliance.

The socioeconomic impacts of the Interchange will mainly come from different solutions using the Interchange. The Interchange itself serves merely as an enabler of services with effects, rather than providing effects by itself. The socioeconomic impacts of the Interchange itself are somewhat abstract, so we also mention some effects from C-ITS services. But without an interchange the data exchange will be limited, and C-ITS services will in many cases not work at all or work much less efficient.

Interviews and literature studies give that there are benefits from services using the Interchange to be made in the Nordic countries such as less congestion, less fatal accidents and non-fatal injury accidents, less CO_2 emissions etc. The earlier studies[33] show large uncertainties in the socioeconomic outcome. There was a cost benefit analysis performed in NordicWay 2, and since there was no definite timing for investments, the project studied the benefit in 2030 compared to possible costs.

“Comparison of the costs and benefits showed that from the road operator perspective, even in the low effectiveness scenario in 2030, the benefits exceed the sum of annual operating and maintenance costs that year and the investment costs up to that year in all countries. In the high effectiveness scenario, the benefits would also cover the operation and maintenance costs of the in-vehicle units in other countries than Finland.” [34]

There were uncertainties in the conclusions, and a major reason is whether the improvements on the roads may lead to an increase in road traffic and thus increased CO_2 emissions (and other effects may be counterproductive). The impact will come by the services, and the service providers need a commitment over time to be able to trust the Interchange to invest in functions relying on/adapted to an Interchange.

The benefits linked to the Interchange network and C-ITS services are mainly benefits for society, which is also the case when building physical road infrastructure. Benefits come within areas such as traffic safety, health, environment, traveling times and traveling cost etc.

The aspect of handling data adds risks concerning data safety and security. There are challenges in owning the data and handling it in ways that are acceptable regarding risk of compromising the right to privacy, and in the bigger picture also safety and security.

Effects can also be seen separated from the transport system itself. Implementing V2G (vehicle-to-grid) and V2H (vehicle-to-home) can play a part in the future electricity distribution system is such an example. It will likely play a part in the future electric system and hence has impacts on the economy, climate, and security.

The interchange can be a part of implementing autonomous driving, and that is an example that has impacts, mainly positive, on spatial planning. It might affect the needs for buses, parking spots in number and in roof heights in parking houses etc. The width of car lanes can be affected, making room for more lanes or other use in some cases.

C-ITS services often need larger traffic flows to create enough positive socioeconomic impact or to work at a satisfactory level. The most benefits from early assessments of C-ITS projects are likely to be along roads with high traffic flows and in cities. There are also C-ITS services that will benefit rural areas such as the Geofencing bearing capacity service mentioned in the impact chapter. The final geographic distribution of effects remains to be seen.

Socioeconomic impact will vary in time depending on when the Interchange is ready and operational. Uncertainties and/or delays with the Interchange will delay wanted effects and positive socioeconomic impact will be missed during that time. A delayed year is a year without

[33] NordicWay 2 – Evaluation results Version 1.0, 16 December 2020

[34] Nordic Way 2 (2020), Evaluation results. Version 1.0

benefits, which is an important point if the services have high benefits compared to its costs. The Interchange might also be a base for more applications to cooperate with each other creating benefits otherwise missed.

Even if the direct or indirect benefits of the interchange can be linked to the private sector, companies and individuals need to understand what their benefits are and be willing prioritize to pay for them rather than other things that may also provide benefits. And the willingness to prioritize to pay for them must be stable over time. Another option is to make companies and citizens pay the implementation and operation of the interchange via taxes. Since it's so hard to pinpoint exactly who benefits direct or indirect from the Interchange, it might be better to take a broader government responsibility. An interchange can also be considered as basic infrastructure, like the road itself, which creates benefits from the ability to move people and gods. The compresence becomes more relevant the more integrated the systems will be with the function of the roads in the coming decades. Basic infrastructure consists of physical and digital solutions in the current and future transport system. Seen as being a provider of basic infrastructure affecting transport system, and possibly even energy systems will affect the countries competitiveness in a broader perspective, and as such will provide income on a grander scale in higher degree of refinement. Therefore, it can be smart for nations to provide that basic infrastructure and gain money back later as companies and people generate more economic values.

6 Reflections and Conclusions

Most countries struggle with challenges in the transport system such as CO2 emissions, high load on the road infrastructure leading to congestions, fatalities, and injuries, not to mention financing of maintenance and new constructions. There is a uniform international opinion that digitalization and C-ITS services will play an important role in overcoming existing challenges. Based on this, many different initiatives have emerged to investigate the advantages that digitalization could bring; the NordicWay project is a good example of such an initiative.

At the European Union level, there are now several initiatives ongoing, as described in chapter 4. The common aim of these initiatives is to create a working C-ITS ecosystem within the EU. A complex digitalized transport system is emerging, but a common and harmonized pathway for the implementation of real-time C-ITS interconnections is still not clear from these initiatives. The NordicWay Interchange could be seen as a solution filling some of the gaps in achieving a harmonized path. It would enable independent systems to collaborate using common interfaces, implemented using common specifications, and thus would enable C-ITS services to be developed by different parties in the ecosystem. The NAPCORE project (see chapter 4.2) has recently (at the ITS EU Congress 2023) described that there is a link between NAPs and an interchange function based on the project C-Roads' specifications. This connection has been further emphasized by a demonstration to connect the Danish NAP and the Norwegian Interchange. Some more countries in Europe are now starting to implement real-time data exchanges based on the C-Roads specifications, e.g., Belgium, and the Netherlands. More are expected to follow.

The Interchange solution developed in the NordicWay project has clearly demonstrated the ability to create a working platform for the exchange of real-time C-ITS messages in the transport system. As it is based on the C-Roads specifications, it is likely to be compatible with other countries implementing data exchanges using the same specifications. If the C-Roads specifications will be the basis for a harmonized, future C-ITS ecosystem in Europe, the NordicWay project is on the path towards this goal. Whether or not the C-Roads specifications will be the basis can however not be determined yet, but the specifications are used by many countries as a de facto standard for C-ITS service definitions.

When looking at the distribution of benefits made possible by the existence of the Interchange, these services have a big societal impact. Piloted services within NordicWay 3 have clear societal impacts which do not necessarily directly benefit the actors offering or implementing the solution. However, within this study, the focus is on the Interchange itself and the assessment of benefits of the Interchange itself is somewhat abstract. The Interchange network is primarily an enabler, both for C-ITS services and future autonomous driving services, to exist, but not the least it is a prerequisite for a federated C-ITS ecosystem. Also, one must not forget the traveller's perspective and the expectation of a harmonized and borderless transport system regardless of road operator and country. Seen from the viewpoint of the traveller, it is expected that the C-ITS ecosystem behaves in the same way in any European country, also when crossing national borders.

One aspect where we have not been able to come to a clear conclusion is civil security. If operating C-ITS services through an Interchange, it is likely that any outage in the operation of the Interchange might lead to disturbances in the traffic and goods flow, and thereby lead to safety issues. This could make the Interchange a target for cyber security threats. This topic needs further investigation. It indicates that setting up an Interchange might have to be a national responsibility, since civil security in the transport system is a national concern and responsibility.

There are still some unanswered questions of how a platform for data exchange and integrations between different organizations should be owned, operated, maintained, and financed. This is a current topic within NordicWay 3 project, where the Nordic countries haven't yet taken all necessary decisions if and how to enable the continuity of the Interchange. To reach a conclusion and take the remaining decisions the generated benefits as demonstrated in NordicWay3 should be considered. Also, how data exchange within the transport system is likely to be regulated in the EU must be considered.

We believe that a systematic governance on national and international level will be required to reach harmonization in such a complex ecosystem within and across borders. Regulations are seen as a crucial factor for how a data exchange platform in the transport system would be owned and operated. The new ITS Directive and upcoming delegated acts will most likely guide how certain data exchange should occur in the transport system within the EU. The European Union ongoing initiatives and working groups related to the data exchange in the transport system aim to harmonize the interpretation and implementation of the ITS Directive. There is a close link between the NordicWay project achievements and these working groups, where the closest is probably with the C-Roads project. The standards being developed by the C-Roads project can be expected to lay the foundation for a real-time data exchange of C-ITS data and services in the future and are utilized by the NordicWay Interchange. Also, at the ITS EU Congress 2023, the NAPCORE project mentioned the concept of the Interchange as a possible solution to the parts of the ITS Directive related to (real-time) data exchange. Despite the effort being invested in the area, so far, the NordicWay Interchange seems to be the most concrete and advanced solution to federated real-time C-ITS currently existing in Europe. Therefore, it is important to continue cooperation in existing working groups on European level.

If decisions on how an Interchange network should be owned, operated, maintained, and financed, are not made by those organizations currently operating the Interchanges, the risk is that the Nordic Interchange network will not exist after the finalization of the research project NordicWay 3. This alternative must be carefully evaluated in terms of what that would mean for the future of the transport system and furthermore Agenda 2030, Vision zero and other societal benefits already decided upon. Additional workload and cost to implement, maintain and comply with coming EU regulation regarding mandatory sharing of data and services must be estimated. It must also be compared to benefits that may arise in society from today, as a possible result from opportunities and services that could emerge based to the Interchange network.

The different standpoints from the Nordic transport administrations create uncertainty among the actors, especially actors from the private sector. Clarity about what will happen with the Interchange network after the ending NordicWay 3 is crucial. Otherwise, the development of services will stagnate, and the expected benefits will most likely disappear, at least for a considerable period in time.

The conclusion is that it would be beneficial to the future development of a real-time C-ITS infrastructure in Europe if the NordicWay Interchanges could remain in operation also after the end of the NordicWay project the 31st of December 2023. We recommend the transport road authorities to prepare for how to govern the future need for a (national) C-ITS digital infrastructure. This includes setting up dedicated parts of the organizations for C-ITS and changing national directives that might collide with the future C-ITS needs. Budgets for this need to be established. In the international projects described above in chapter 4, the development pace and the budgets reserved for C-ITS deployment are increasing and now seem to be higher than in the Nordic countries. Also, the private sector, led by the OEMs, seem to have a higher pace of development than the Nordic Road Authorities, and it is important for all parties that the road authorities keep at least the same pace of development.

7 Recommendations

1. **Continue financing the Interchanges that are already deployed**

   The reason is that there is a lot of experience to be drawn from the Interchange Ecosystem in the coming years. It should be announced for how long they will be financed to create trust and stability for the actors in the ecosystem.

2. **One interchange per country will be minimum, but yet sufficient**

   Technically, one interchange is capable of serving more than one country, but since the interchange might pose a civil security risk, it should be operated within one country. It is the country that has the overall civil security responsibility.

3. **Establish national security guidelines/rules for an Interchange**

   There are no established guidelines for security developed in the Nordic Countries yet. A permanent deployment of an interchange should be supported by valid security guidelines.

4. **The Interchange shall be owned, financed and maintained by a public authority**

   The reason is that it creates trust, visibility, and long-term responsibility. We believe that the most likely authority is the road authority. This has been a request from the private parties in the NordicWay 3 project.

5. **Establish the necessary responsibilities and authorities for operation of the Interchange**

   This should be done independently per public authority in charge, and per country.

6. **Align the Nordic countries' solutions for C-ITS, including the Interchange**

   This will make the solutions developed in NordicWay 3 interoperable and more trustworthy on an international level.

7. **Define and establish a continued cooperation between the Nordic road authorities for C-ITS**

   We know that there exists a cooperation arena already, but since NordicWay 3 closes down, the level of cooperation established in the project will disappear and there might be a need to increase the amount of normal cooperation.

8. **Establish an arena for cooperation with the private sector (OEMs) after the end of NordicWay**

   We know that there exist cooperation arenas already on a case by case basis, but since NordicWay 3 closes down, the level of cooperation established in the project will disappear and there might be a need to increase the amount of normal cooperation.

9. **Continue to participate in the EU financed working groups, e.g. EMDS, C-Roads**

   The long-term establishment of a C-ITS ecosystem will have to be on (at least) a European level, it will not be sufficient with only the Nordic countries. Participating in the development of this common ecosystem and contributing with all the knowledge built up in NordicWay 3, will be crucial.

10. **Differences and relations between Interchange and National Access Point (NAP) needs to be described**

    There is a wide range of understanding (some not right) of the relation between a NAP and an interchange. In particular, it seems like many decision makers believe that they

are the same. The implementation regulations for a NAP is governed by the project NAPCORE (see §4.2).

Appendix: List of interviewees

No	Actor	Task/Role
1	Traficom	Activity lead (FI)
2	Traficom	Contact person
3	Trafikverket	Activity lead (SE)
4	Statens vegvesen	T2 Architechture and Services (NO) T5 Norwegian Pilot
5	Statens Vegvesen	Steering group WP 1.3
6	Vejdirektoratet	T5 Service definitions and standards (DK) T2 Specification, service definitions and user interaction (DK) &
7	Statens Vegvesen	Activity lead (NO)
8	Sweco	Activity lead, Pilot Coordination (SE) and T5 Geofence
9	Trafikverket	Activity lead, Pilot Coordination (SE) and T5 Geofence
10	Statens Vegvesen	T2 Traffic Signal Information
11	Carmenta	T3 Emergency Vehicle Alert (EVA)
12	SOS Alarm	T3 Emergency Vehicle Alert (EVA)
13	Trafikverket	T4 Road Works Warning (RWW)
14	Statens Vegvesen	Activity lead (NO)
15	Monotch	T3 Swedish pilot
16	Vejdirektoratet	T2 Specification, service definitions and user interaction (DK)
Round 2		
17	Volvo Cars	System Architect Autonomous Drive
18	Volvo Cars	Contact person
19	Trafikverket	Enterprise Architect inom Ekonomi och styrning, IT styrningsfrågor
20	Trafikverket	Department Manager IKT Väg-IT
21	Trafikverket	Enterprise Architect inom Ekonomi och styrning, IT styrningsfrågor
22	Trafikverket	Advisor ITS and coordinating role for response on ITS Directive
23	Trafikverket	Senior Advisor and Development Manager for Traffic Management, ITS and data
24	GAIA-X (SE)	Coordinator of the Swedish Gaia-X Hub

25	Regeringskansliet	Desk Officer at Digital Society Division, Ministry of Infrastructure
27	Scania	Contact person
28	Transportstyrelsen	ITS and Vehicles
29	Volvo Cars	Business Developer
30	AFRY	Senior ITS Consultant
31	Monotch	T3 Swedish pilot
32	Combitech	Contact person
33	Swarco	Contact person
34	HERE	Contact person
35	Trafikverket	Civil Security
Round 3		
36	MSB	Cyber Security
37	National emergency supply agency (NESA, Finland)	Chief Preparedness Specialist, Logistics