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National Road Authority guidance on legal and ethical use of data

Deliverable 6 Version 1.01

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Trusted Integrity and Authenticity for Road Applications (TIARA)

Deliverable 6: National Road Authority guidance on legal and ethical use of data

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Executive summary

The objective of TIARA project's Work Package 3 (WP3) Legal and Ethical Aspects was to review the legal and ethical ramifications for NRAs when making use of C-ITS data, and of how these change the role of the NRA.

Methods of the study were literature review, interviews, workshops, and collaboration with the other TIARA project's work packages of security (WP2) and privacy (WP4), as well as CEDR Project Executive Board (PEB) and CEDR Data Call 2022 projects DROIDS and PRESORT collaboration in the workshops.

The conclusions for the six research objectives are summarised below.

1. Guidance on the responsibility of the road authority to ensure that data is accurate, and the accountability when inaccurate data is sent.

There are no direct technical requirements outside of required data formats (DATEX II, etc.) related to ITS or C-ITS data accuracy nor quality in European legislation. However, Member States are required by legislation to set up NAPs, make the data available, communicate inaccuracies (in collaboration), provide parameters of the quality of the data update, and follow minimum quality requirements that are agreed in cooperation with relevant stakeholders (RTTI 2022/670). These are further implemented in a Member State, depending on legislation and policies, by the road operator or National Road Authority (NRA). Other ITS and C-ITS relevant European legislation included the Product Liability Directive (EU) 2024/2853 which concerns software and related services; navigation systems providing traffic data are mentioned as an example of determining the safety of the product just as much as physical or digital components and having a possible liability.

2. Guidance on best practice for the communication of data and its limitations with road users

The most important aspect is to know who the users are and what are their needs; the users need to be consulted throughout data and service development life cycle. Furthermore, road user groups were presented to provide examples and development guidance. Also, different user groups communication needs were given to provide example of user requirements.

The main channel for data publication is the NAP, and for the C-ITS data the national or regional interchange nodes or clouds. The road operators should also keep the data users aware of the quality of the data published.

The first road user group contained different road user stakeholders as referred in the ITS Directive (EU 2010/40) definition, such as vehicle owner or vulnerable road users. The second group had specialised road user groups, such as people who are mobility impaired or disabled with specific needs, to include when communicating and developing inclusive data and services.

3. Views on how to be open and transparent with roads users on the use of data were combined with the research objective **4. Review of how communications around the use of C-ITS systems and data can be ensured to be inclusive of road users across technical ability.** The following categories, which each included further recommendations, for transparent and inclusive communication were given mainly based on UK Government Data Quality Hub (2021) and workshop results:

- Follow legislation, rights and principles

- Explain importance of data quality communication
- Develop effective, bidirectional communication with users and stakeholders
- Make communication user-centric
- Make communication accessible and inclusive
- Practice transparent and reliable data quality and service communication
- Ensure privacy and data protection in communication
- Communicate in a timely and responsive manner
- Engage with data providers and users
- Provide education to users
- Provide communication guidelines for all communication
- Create a process for continuous communication monitoring and development
- Practice proactive risk management in communication

Research objective **4.** was also separately studied to give **guidance on developing C-ITS services that are inclusive of road users across technical abilities.** The following conclusions were made:

- Road user technical abilities need to be reflected in the HMI and human-factor user interface development. Inclusive, universal and usability principles can be used to make systems easy to use for all users so that the users can reach their task goal. These principles and best practices were referred in the study chapter 6.5.2 “Service development industry standards, guidelines and recommendations” and should be followed in collaboration with the industry.
- Legislation and regulation related to service development as well as HMIs is not direct nor there are set legislative requirements. Indirect legislative references can be identified in the ITS Directive (2010/40/EU) that defines basic ground for safe services. The European Commission gave recommendations for safe and efficient in-vehicle information and communication systems (2008). Although in-vehicle systems have developed considerably after the recommendations, they are still valid, and the recommendations can be applied.
- Road operator responsibility on services also extends to the agreements and contracts made for example with road maintenance contractors. As an example, if a contractor has been required to use a service or third-party application as a part of a road works, the service usability need to be ensured by the road operator.
- Barriers and opportunities presented in the literature and in the workshops included simplifying GDPR compliance messaging, lack of inclusive regulation and enhancement of co-creation. Especially the latter co-creation requires close collaboration between road operators, private industry and road users to ensure the user needs are met to develop inclusive and safe services. Although it was identified that there was lack of inclusive or HMI regulation, the study results did not provide evidence for a need of a such regulation as its upsides and downsides should be further considered, in collaboration with the industry.
- Development of inclusive services requires extensive piloting, testing, simulation and modelling in conjunction with the road users to understand user and service needs and requirements. Validation and verification with service metrics need also to be considered. If a road operator decides to develop its own services, these requirements need to be understood with careful considerations and has to evaluate, whether the service and use case development is a priority part of its core business. Risks need to be addressed when using multisided business models with the industry as this could lead to high development and maintenance costs. Possible gaps between services and road operator responsibilities can be evaluated when deciding, including also ethical considerations.

5. Lessons from other industries on the ethical use of data, the following data ethics conclusions were presented.

Data ethics principles and actions proposed in the UK government Data Ethics Framework (2020) are recommended as guidance for the road operators and contractors working for them. This framework has both overarching principles and specific actions. The overarching principles of transparency, accountability and fairness are applicable across the entire process. The specific actions guide through different stages of the road operator operations and provide practical considerations.

C-ITS pilots and deployments will provide practical and best insight to legal and ethical issues and solutions which should be documented and shared with the community.

It is ethical for the road operators to provide open data and share openly their responsibilities and data quality.

The study gives three strategic, tactical and operational level recommendations for road operators based on ITS and other industries lessons on ethical use of data which include implementation of code of ethics and its implementation at an organisational level.

6. Analysis of the information about road users that could be leaked from C-ITS data and the potential impact on the data subject. This research objective was mainly studied in the TIARA deliverable on Privacy in C-ITS Applications. This study covered and concluded the following from the objective:

- Data and services delivered by the NRA or its subcontractors, will be the responsibility of the NRAs.
- Inclusive communication requires that a wide range of user groups are identified and based on the recommendations this study informed as to privacy measures of the delivered services and their impact.
- It is ethical to communicate risks and possible leaks that may have occurred to the road users with potential impact and recommended actions to mitigate. The recommended ethical process established in the organisation and following the recommended data ethic principles in this study will help to establish the NRA data ethics policy.

The following guidance and recommendations for the future were given for the road operators based on our results:

1. The NRA should embed legal, contractual and ethical responsibilities for data accuracy in their operation
2. Identify the road users and involve them in communication and real-world development of the services
3. Understand and acquire expertise on C-ITS services, use cases and their limitations
4. Follow inclusive and transparent communication recommendations
5. Develop inclusive services by using the Human-Centered design principles
6. Apply basic principles and processes for ethical use of data
7. Carry out risk evaluation when communicating and developing ITS/C-ITS services

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We acknowledge the importance of the support from the CEDR European road operators and the other TIARA project partners for the carrying out and completion of the study on

legal and ethical aspects of C-ITS and the ITS applications. We thank all public authority, research and private industry participants at the workshops and interviews as well as those providing feedback to the draft reports and answering our questions via email. Special thanks to Maxwell Ash (National Highways), Tuomo Kujala (University of Jyväskylä) and Peter Lewyllie (Flemish Road and Traffic Agency) for providing insight.

TIARA project description

The objective of the TIARA project (*Trusted Integrity and Authenticity for Road Applications*) is to provide the National Road Authorities (NRAs) with an increased understanding of what is required to achieve a trustworthy and secure data infrastructure. The availability of data has allowed road users and NRAs to benefit from new business models. To deliver these benefits, the data infrastructure must be trustworthy and trusted, i.e., secure, with assurances that it is managed to achieve privacy for all stakeholders.

As more C-ITS services develop in Europe, and road users access and share more C-ITS data through open border countries, NRAs will need to ensure greater interoperability through common approaches to connected systems. Data trust is therefore paramount.

CEDR is undertaking a series of projects to research how NRAs can maintain and share the digital road infrastructure data and improve the use of third-party data by NRAs.

Since the C-Roads Platform has started, several ITS programmes have been rolled out and it has been identified that there are key elements that the NRAs will need to understand before implementing these systems more widely. The TIARA project has been designed to address the two key areas of Trust and Privacy in C-ITS applications. The first subject Trust concerns an understanding of the implementation of trust models that could protect C-ITS data. The second subject Privacy concerns an understanding of the impact of processed user personal data, including location.

Three broad research areas that have been identified:

- Trust for C-ITS applications to develop practical guidance for the implementation of PKI infrastructure for C-Roads,
- Legal and ethical ramifications for NRAs when making use of C-ITS data, and of how these change the role of the NRAs,
- Privacy impact of the processed road user location data, and recommendations to improve the location privacy-preservation for NRAs.

An experienced team of European research organisation have gathered under the coordination of AESIN/Techworkshub, the UK-based member trade association. To address this complex topic, we recognise that the best approach will be through network engagement with many organisations and individuals with experience and technical expertise, preferably independent of any specific solution vendors.

AESIN/Techworkshub belongs to the Techworkshub organisation, through which it has access to member experts in both transport and Internet-of-Things (IoT) security sectors.

SINTEF, as an independent and non-profit research organisation, has independent technical expertise and deep experience from PKI deployments in multiple sectors.

Traficon has longstanding experience of independent work with NRAs, specifically legal and ethical expertise of particular relevance to this project.

TML, bridging the gap between university and private sector, is an independent open and transparent organisation with extensive experience of data analyses and privacy ramifications.

Linking the three broad research areas identified to expertise of these organisations provides a natural project delivery structure, which will benefit CEDR and all the stakeholders involved.

A key TIARA objective is to deliver the project in close liaison with CEDR and its members, as well as the two research projects funded in the CEDR 2022 Research call on Data, Topics A (DROIDS) and B (PRESORT). The liaison ensures that results are fully compliant with CEDR

and Programme Executive Board (PEB) expectations. The liaison also guarantees that the DROIDS and PRESORT projects have the possibility to utilise TIARA results and vice versa.

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Glossary

ADAS	Advanced Driver Assistance System
ADS	Automated Driving System
AV	Automated Vehicle
C-ITS	Cooperative Intelligent Transport Systems
C-Roads	C-Roads Platform is a joint initiative of European Member States and road operators for testing and implementing interoperable C-ITS services for European road users.
C2C	Car 2 Car
CAV	Connected and Automated Vehicle
CCAM	Connected, Cooperative, and Automated Mobility
DoRN	Description of Research Needs
HCD	Human-Centered Design
HMI	Human Machine Interface
EC	European Commission
ETSI	European Telecommunications Standards Institute
EU	European Union
ICT	Information and Communications Technology
IoT	Internet-of-Things
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITS Directive	Directive of Intelligent Transport Systems, (EU) 2023/2661 Directive
NAPCORE	The National Access Point Coordination Organisation for Europe
NHTSA	U.S. Department of Transportation, National Highway Traffic Safety Administration
NRA	National Road Authority
OEM	Original Equipment Manufacturer

PEB	Programme Executive Board
PIARC	Permanent International Association of Road Congresses, World Road Association
PKI	Public Key Infrastructure
RTTI	Real-time traffic information, (EU) 2022/670 delegated act
SAE	Society of Automotive Engineers
SRTI	Safety Related Traffic Information, (EU) 886/2013 delegated act
TIARA	Trusted Integrity and Authenticity for Road Applications
TISA	Traveller Information Services Association
UCD	User-centered design
UX	User experience
WP	Work package

1 Introduction

1.1 About TIARA

1.1.1 Background

The objective of the *Trusted Integrity and Authenticity for Road Applications (TIARA)* project was to provide National Road Authorities (NRAs) with an improved understanding of what is required to achieve a trustworthy and secure connected vehicle data infrastructure. The availability of data has allowed road users and NRAs to benefit from new business models. To deliver these benefits, the connected vehicle data infrastructure must be trustworthy and trusted, i.e., secure, with assurances that it is managed to achieve privacy for all stakeholders.

As more Cooperative Intelligent Transport Systems (C-ITS) services develop in Europe, and road users access and share more C-ITS data through open border countries, NRAs will need to ensure greater interoperability through common approaches to connected systems. Data trust is therefore paramount.

CEDR undertook three projects to research how NRAs can maintain and share the digital road infrastructure data and improve the use of third-party data by NRAs. The TIARA project was delivered in close liaison with CEDR and its members, as well as the two further research projects funded in the CEDR 2022 Research call on Data, Topics A (DROIDS, 2023) and B (PRESORT, 2023), introduced in the below figure.

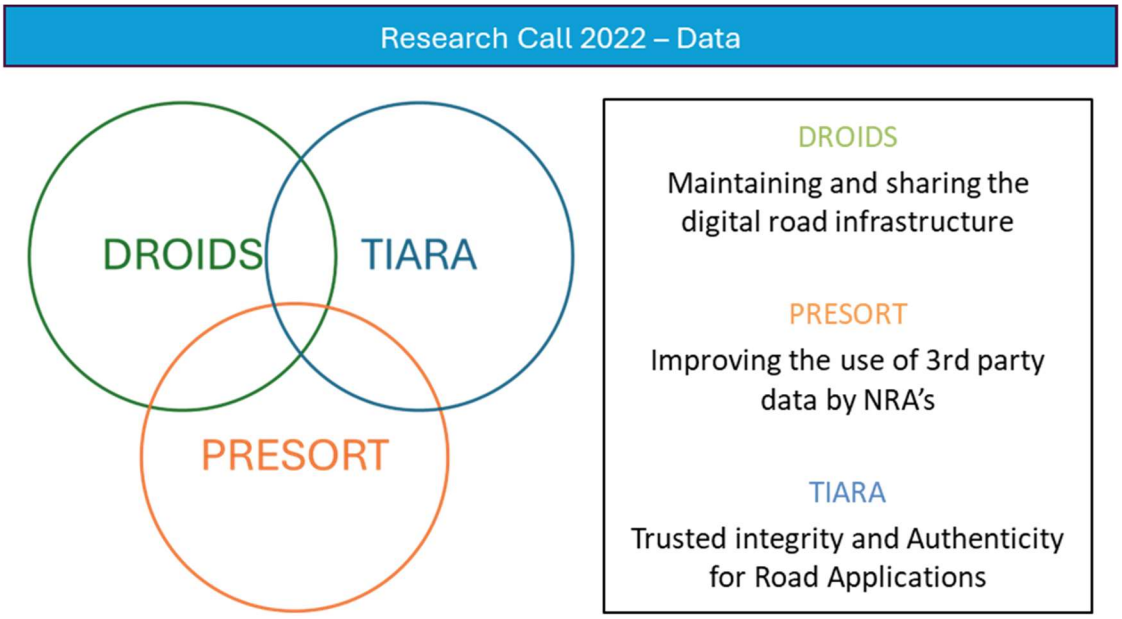

Figure 1 Three projects in the CEDR 2022 Research call on Data.

Since the C-Roads Platform has started (C-Roads, 2024), several Intelligent Transport Systems (ITS) programmes have been rolled out and it has been identified that there are key elements that the NRAs will need to understand before implementing these systems more widely. The TIARA project has been designed to address the two key areas of Trust and Privacy in C-ITS applications. The first subject, Trust, concerns an understanding of the implementation of trust models that could protect C-ITS data. The second subject, Privacy,

concerns an understanding of the impact of processing user personal data, including location.

Three broad research areas that have been identified:

- Trust for C-ITS applications, to develop practical guidance for the implementation of PKI infrastructure for C-Roads,
- Legal and ethical ramifications for NRAs when making use of C-ITS data, and of how these change the role of the NRAs,
- Privacy impact of the processed road user location data, and recommendations to improve the location privacy-preservation for NRAs.

An experienced team of European research organisation have gathered under the coordination of AESIN/Techworkshub, the UK-based member trade association, to address this complex topic through network engagement with organisations and individuals possessing experience and technical expertise, yet independent of any specific solution vendors.

AESIN/Techworkshub belongs to the Techworkshub organisation, through which it has access to member experts in both transport and Internet-of-Things (IoT) security sectors.

SINTEF, as an independent and non-profit research organisation, has independent technical expertise and deep experience from PKI deployments in multiple sectors.

Traficon has longstanding experience of independent work with NRAs, specifically legal and ethical expertise of particular relevance to this project.

TML, bridging the gap between university and private sector, is an independent open and transparent organisation with extensive experience of data analyses and privacy ramifications.

1.1.2 European Cooperative Intelligent Transport Systems (C-ITS) and Services

C-ITS is a subset of standards for ITS. C-ITS services exchange trusted and secured data between vehicles, roadside infrastructure, control and services centres in the cloud, and other road users. The European framework for trusted and secure C-ITS communication, using Public Key Infrastructure (PKI), is the European Union C-ITS Security Credential Management System (EU CCMS) (C-Roads, 2024).

ITS use information and communications technology in transport including infrastructure, vehicles and users, as well as traffic and mobility management. Interfaces with other modes of transport are also included. ITS aims to improve transport safety, reliability, efficiency and quality (C-Roads, 2024).

C-ITS services are ITS services that are provided using V2X communications as agreed in C-ITS specifications. The C-Roads Platform defines C-ITS service or “application” as “a clustering of use cases based on a common denominator, for example, an objective such as awareness or a context like road works” (C-Roads, 2024). C-ITS services in Europe have been proposed under EU strategies and studies, such as European Commission (EC) COM(2016) 766 and C-ITS Platform (2016) (CCAM, 2021). The services, and their timeframe for likely implementation, are indicated in the figure below.

The C-Roads Platform has also defined European C-ITS specifications. These comply to C-ITS standards. The CAR 2 CAR Communication Consortium (C2C-CC) has developed the Basic System Profile, which has been harmonised in the C-Roads specification for road infrastructure. C2C-CC members include European and international vehicle manufacturers, equipment suppliers, engineering companies, road operators and research institutions (C2C-CC, 2002).

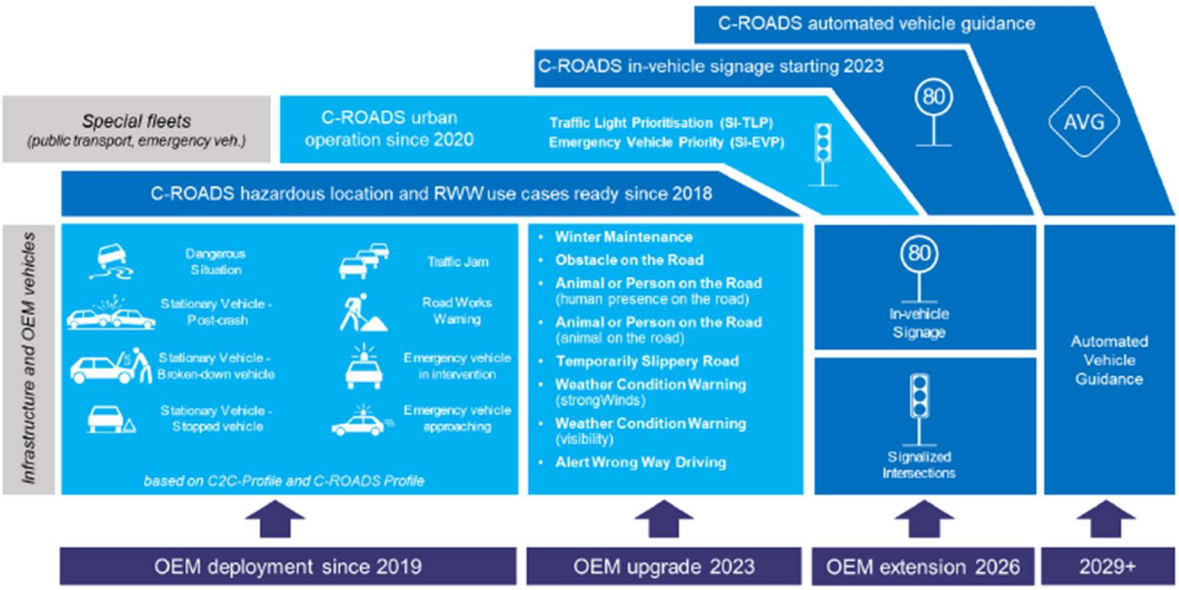

Figure 2 The C-Roads Platform for harmonisation of C-ITS deployment.

1.1.3 European C-ITS Pilots and Issues

Since C-Roads started, several European trials of C-ITS have been ongoing. However, there are elements that road authorities will need to understand before implementing C-ITS systems more widely:

- Roll-out of PKI systems

The PKI systems required for C-Roads and C-ITS systems are comparatively complex. Certificates are generated and loaded into a vehicle, and are regularly rotated for security and privacy reasons, meaning that there is a large throughput of certificates. The PKI infrastructure needs to support this generation of certificates and needs to support the regular verification of messages. Road authorities need support and guidance to better understand how to implement the PKI systems required.

- How NRA's ethical and legal obligations change with connected road infrastructure

C-ITS systems represent an evolution of the role of the road authority, from building and maintaining roads, through traffic management technology, to directly transmitting data to the road user. This is a change in the responsibility of the NRA. The NRA needs to ensure that the data they provide maintains integrity, that the road user understands the data they are receiving, and how the collected data is being used. As such, NRAs must understand their ethical responsibilities to customers and other users of the data that they collect.

- Privacy of road operators' customers' data

To ensure road users trust the lawful and sensible use of their data by road operators, road authorities must be open and transparent about the data that is collected and for what it is used or could be used. Opinion 3/2017 of Art. 29 Data Protection Working Party indicates that identifying the physical location of a road user can be sufficient to trace back to an individual in a population (taking account of regular travel patterns within certain precision). Several European road operators process location data from road users to optimise signalised

intersections (e.g., Flanders and the Netherlands) or to warn about slow moving vehicles. Measures must be implemented to make such re-identification more difficult, and road authorities should understand to what extent these measures are sufficient to make reidentification "reasonably" impossible.

1.1.4 TIARA Project Scope

The scope of the study and key concepts were defined in collaboration with CEDR and the TIARA project partners, and were limited primarily to C-ITS. Stakeholders from independent organisations and individuals with key expertise also provided input for the project scope through workshops. The linkages to other CEDR research project scopes are indicated in the figure below.

Secondary technologies also include ITS. Although ITS have different standards and specifications than C-ITS, it was seen beneficial to have broader views and experiences on data accuracy, quality, and accountability, and the consequences of inaccuracy.

While C-ITS services have been implemented in recent years at the European roads, there is significantly more experience on traditional ITS services and data accuracy. Furthermore, many ITS services have similarities with the initial C-ITS services, e.g., so called "Day 1 services", with differences around the communication medium, standards, specifications and communication protocols. For example, road operators may already share slippery road warnings to road users using ITS or C-ITS.

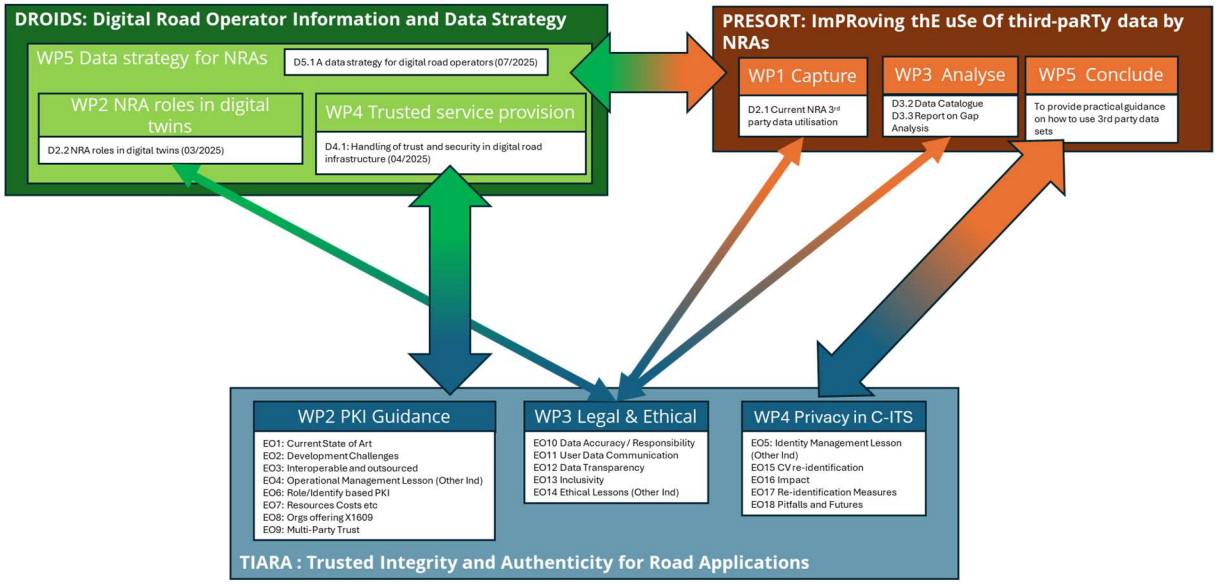

Figure 3 Linkages between scopes of the three CEDR research projects.

1.2 Study Scope and research questions

Scope of the study and key concepts were defined in collaboration with the sponsor of the study Conference of European Directors of Roads (CEDR) and the TIARA project partners. Project stakeholders of independent organisations and individuals with key expertise have also provided input for the project scope.

The Term *"road operator"* is mainly used in this study except of the introduction chapter and research questions to describe any public or private entity that is responsible for the planning,

maintenance and management of the road, including management of traffic flows. The use of term road operator aims to clarify that the legal and ethical responsibilities concern both public and private road operators, not only authorities. The use of term "road operator" is also described as follows in CEDR study of Soni et al. (2025) (notes made by the writer of this study in the below quote has been marked with square brackets, i.e. "[ ]"):

> *"The term [road operator] has been here adapted from the European Commission delegated regulation (EU) 2022/670 of real-time traffic information services (EC 2022). The term National Road Authority (NRA) is often used in Europe to describe a Member State national authority that is responsible for the previously mentioned tasks; in this study, the term road operator is also used to cover NRAs [National Road Authorities]." (*Soni et al. 2025)

Scope of the study limits according to the National Road Operator research needs primarily to Cooperative Intelligent Transport Systems (C-ITS). Scope in this study also covers Intelligent Transport Systems (ITS) technologies and services as being the umbrella for C-ITS and further explained in the paragraphs below.

The goal of the work package was to review the legal and ethical ramifications for NRAs when making use of C-ITS data, and of how these change the role of the NRA. Therefore, the primary technology studied in the TIARA project and this work package is C-ITS.

The secondary technologies included in the study are (other) Intelligent Transport Systems (ITS). Although ITS have different standards and specifications than C-ITS, it was seen beneficial to have broader views and experiences on data accuracy, quality and accountability, and the consequences of inaccuracy. While C-ITS services have been implemented in recent years at the European roads in some countries, there is significantly longer experience on traditional ITS services and data accuracy. Furthermore, many ITS services have similarities with the current C-ITS services, e.g., so called Day 1 services, as the main difference of these services comes mainly from used communication medium, standards, specifications and communication protocols. For example, road operator may share slippery road warning to road users using ITS and/or C-ITS.

The European National Road Authorities' (NRA), or road operators, responsibilities include planning, development and maintenance of physical infrastructure with related coordination of land use as well as traffic control and management. In the era of digitalisation, an important related NRA responsibility is to collect, manage and share relevant data. Improvements in traffic safety, efficiency and sustainability are expected with real-time and traffic safety related data which is also exchanged by Cooperative Intelligent Transport Systems (C-ITS). C-ITS services are managed by different public and private stakeholders that provide services for the end users on the road network. To gain the safety, efficiency and sustainability benefits, the NRAs have been deploying C-ITS infrastructure in collaboration with the industry.

In addition to C-ITS requirements of secure data infrastructure and trusted messages, legal and ethical ramifications for NRAs when making use of C-ITS data and the role the NRA in the C-ITS ecosystem need to be determined and understood to provide safe, trusted and sustainable services for the road users.

The objective of TIARA project's Work Package 3 (WP3) Legal and Ethical Aspects was to review the legal and ethical ramifications for NRAs when making use of C-ITS data, and of how these change the role of the NRA. The expected outputs are as follows:

1. Guidance on the responsibility of the road authority to ensure that data is accurate, and the accountability when inaccurate data is sent.
2. Guidance on best practice for the communication of data and its limitations with road users.

3. Views on how to be open and transparent with road users on the use of data
4. Review of how communications around the use of C-ITS systems and data can be ensured to be inclusive of road users across technical ability. Guidance on developing C-ITS services that are inclusive of road users across technical abilities.
5. Lessons from other industries on the ethical use of data
6. Analysis of the information about road users that could be leaked from C-ITS data and the potential impact on the data subject.

The WP3 Legal and Ethical Aspects has worked in collaboration with the TIARA WP2 PKI Guidance Development and WP4 Privacy Review to achieve the set goals and expected outputs as both WPs have provided input to this deliverable.

The deliverable includes the following chapters: Chapter 2 Methodology describes the methods used, Chapter 3 an introduction to C-ITS actors and roles, value chain of traffic information and definitions of data accuracy and quality. Chapter 4 Responsibility of data accuracy highlights and studies European legislation, policies, contractual agreements, authorities and industry views as well as case studies. Chapter 5 Ethical use of data continues to study and analyse responsibility from an ethical perspective. Chapter 6 presents inclusive communication and development of C-ITS services to road users. Finally, guidance and recommendations are given to road operators in Chapter 7 and conclusions of the study in Chapter 8.

2 Methodology

The study origins from the Conference of European Directors of Roads (CEDR) Transnational Road Research Programme Call 2022(2). CEDR brings together the General-Directors of European road authorities and road operators' experts with knowledge of the core business and its engineering. The study's expected outputs were derived from the CEDR Call's Description of Research Needs (DoRN).

The study's research plan and research questions, following the CEDR expected outputs, were presented in the submitted proposal's Work Package 3 (WP3) work description. The plan specified the key methods of literature review, interviews, workshops, and collaboration with the other TIARA project's work packages of security (WP2) and privacy (WP4), CEDR Project Executive Board (PEB) and CEDR Data Call 2022 DROIDS and PRESORT projects.

The selected methods aimed to cover wide range of stakeholders among the public authorities and traffic information service providers to gather best possible professional expertise in the field.

The literature review was based on academic and industry research papers, conference proceedings, European legislation as well as guidelines and use case papers regarding legal and ethical use of data.

Interview contacts were made when requesting additional information after the workshop from the workshop participants. Also, other experts recognized in the field, e.g. research and industry, were interviewed.

Workshops were conducted in collaboration with the two TIARA work packages of security and privacy. European ITS platforms, companies and projects with relevant expertise were mapped in collaboration and invited to provide feedback to the study.

First workshop on 7th of May 2024 "Road operator responsibility on data accuracy as well as accountability of inaccurate data" main results are introduced in the chapter 4.4.3. Six participants (n=6) took part in the workshop where participants represented public authority, private industry and research organisations. The first workshop material can be found in APPENDIX 1.

Second and third workshops on "Ethical ITS/C-ITS content and service provision to users" were arranged on 4th and 5th of November 2024. Five participants (n = 5) took part in 4th of November workshop and four participants (n = 4) on the 5th of November workshop, therefore total of nine participants (n = 9) joined the workshops. The participants represented public authority, private industry and research organisations. The results are presented in chapters 5 and 6. The second workshops material can be found in APPENDIX 2.

In addition, a session on data accuracy and related road operator liability was organised in connection with the CEDR Programme Executive Board (PEB) meeting in Ghent on 18 June 2024. The results of this are reported in chapter 4.

Collaboration with the other CEDR Data Call 2022 projects DROIDS, i.e., Maintaining and sharing the digital road infrastructure, and PRESORT, i.e., Improving the use of third-party data by National Road Authorities (NRAs), was limited mainly to the topics of trust and security when offering traffic information services and data.

3 C-ITS roles, value chain and data accuracy

3.1 C-ITS actors and roles

C-ITS actors and roles include a great number of public and private entities with different responsibilities with a joint aim of C-ITS service operations coordination. The four top-level roles have been defined in the ISO TS 17427-1 as in the Figure 4 below.

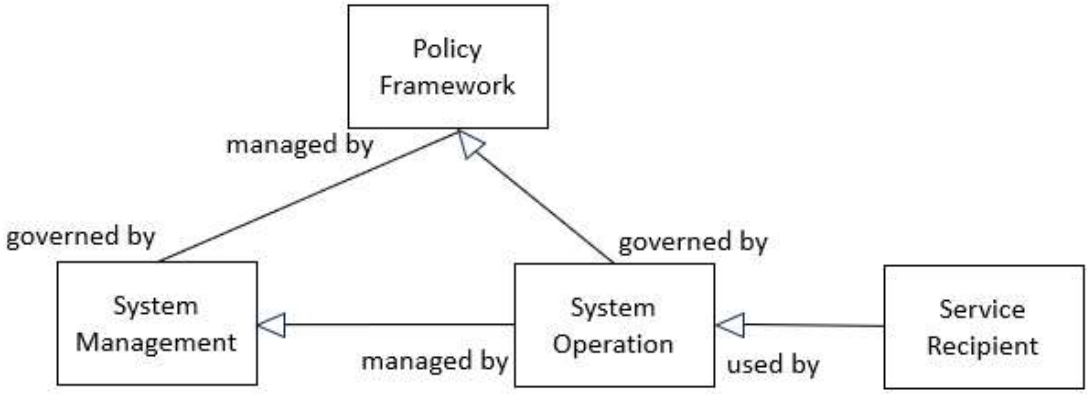

Figure 4 C-ITS roles and responsibilities adapted from ISO TS 17427-1.

C-Roads Platform WG1 C-ITS Organisation draft report titled as "Ecosystem for fully operational C-ITS service delivery – The infrastructure perspective" (2022) and C-Roads Platform 'Report on legal structures' (2018) present key roles which are summarised in Table 1 C-ITS actors and roles.

Table 1 C-ITS actors and roles.

Actor	Roles
Public Authority	Government or other public administration operator, such as national, regional, local (e.g., municipality) or other person performing their legal duties.
European Commission	Politically independent executive body of the European Union. Supports for example in C-ITS related research, implementation, investments, legislation and coordination.
Infrastructure operator	Road operator, rail network operator, public transport rail network operator or a third party as a concessionaire on behalf of a public authority, responsible for operating a specific transport infrastructure.
Component and equipment suppliers	Companies that for example are manufacturing of equipment, materials, spare parts and components for C-ITS services.
Automotive industry	Original Equipment Manufacturers (OEMs), i.e. vehicle manufacturers as well as their device and software providers.
Mobile Network Operators	Mobile communications network provider (e.g., 4G and 5G). Provides of communication networks for vehicles and infrastructure, and a license to operate the network as an operator.
Service provider	Third-party service providers, such as map producers and companies that provide telecommunications services as a

	service, offering access to for example road operators and equipment manufacturers to the data and geomessaging technologies needed to produce C-ITS services.
C-ITS service operators	Road operator, an original equipment manufacturer or a third party such as a map manufacturer or an information traffic service provider that provides C-ITS services to an end user or another organization. Also supporting and planning the platforms required by the services (e.g. cloud services).
National Access Point (NAP) provider and nominated body	Provides access, exchange and re-use of traffic-related data. Requirements are part of the ITS directive and its delegated regulations. Possibly supports and implements some C-ITS functions. The conformity to the requirements is assessed by nominated bodies.

It should be noted that also many C-ITS-like services, i.e. such as ITS services, exist that provide messages of similar actual content but not fully aligned with the C-Roads specifications. Most of the conclusions in this deliverable likely apply to these services as well. This has been acknowledged also in the earlier chapter of Study Scope.

3.2 Value Chain of Traffic Information

Value Chain of Traffic Information and data flows of C-ITS and ITS services can be divided into content and service sides. The content side includes content detection or collection and content processing. The services side includes service provision and service presentation.

C-ITS actors may have different roles in the value chain, for example depending on the C-ITS or ITS service, the content side can be provided by a public authority and service side by a service provider. Each step of content or service provision includes communication of the traffic information. The content and service provision ends when the end user receives the traffic information. (EU EIP C-ITS Quality package (2022) and TISA Position on Quality of Traffic Information (2016))

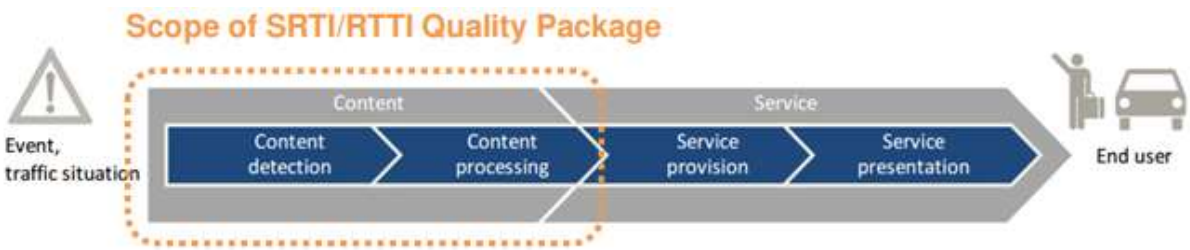

Figure 5 Value Chain of Traffic Information based on TISA and adapted from the EU EIP C-ITS Quality package (2022) and TISA Position on Quality of Traffic Information (2016).

The study's research questions concern the whole Value Chain of Traffic Information as communication of data, or content, and inclusive service provision are studied. The value chain is reflected in the study's chapter 6 Inclusive communication and development of C-ITS services to road users, where both the content and service part of the value chain are discussed, and later in the final chapters of guidance and recommendations as well as conclusions.

3.3 Data accuracy and quality

The ISO (International Organization for Standardization) 8000 series provide frameworks for improving data quality for specific kinds of data. The scope includes for example data quality general aspects, governance, management, assessment as well as master and industrial data.

Data accuracy is defined in ISO 8000-2:2022 Data quality part 2: Vocabulary (3.8.10), which defines terms related to data quality, as follows:

> *"Quality of data in respect of the represented value agreeing with the corresponding true value to a degree necessary for an intended purpose"*

Data quality is furthermore defined in the similar ISO 8000-2:2022 standard (3.1.3) and ISO 9000:2015 as "*degree to which a set of inherent characteristics of an object fulfils requirements*." For example, an organisation has needs or expectations, i.e., set of requirements, that it includes to a data specification. Furthermore, relevant inherent characteristics of the data determine how to interpret the value, e.g., traffic information inherent characteristics could include location coordinates with preferred latitude and longitude accuracy.

Data accuracy depends on the details of the data representation, subject matter and purpose to which the user intends to put the data. For example, traffic information service provider might have a requirement for a location accuracy of the data that needs to be inside of an accepted reference value (as true value might be difficult to obtain). There are no universal specifications for data accuracy. (ISO 8000-2:2022)

Following terms and definitions are related to data quality role in the ISO 8000-2:2022:

- *Responsibility*: combination of activities, decision making and achieving outcomes, where the combination is performed by a specified party.
- *Role*: set of responsibilities, where the set can be assigned by an organization to a person and this assignment directs the person to perform each responsibility.

The ISO/IEC 25000:2014 Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) series also deals with data quality. The ISO/IEC 25012:2008 includes a data quality model for information systems (ISO/IEC 25000:2014, ISO/IEC 25012:2008, Datos, ISO25000). Data quality is defined as follows:

> *"Degree to which the characteristics of data satisfy stated and implied needs when used under specified conditions."*

The Data Quality model presented in the Figure 6 Data Quality characteristics main categories (ISO/IEC 25012). below includes main characteristics that must be taken account when assessing the properties of the intended data product are established.

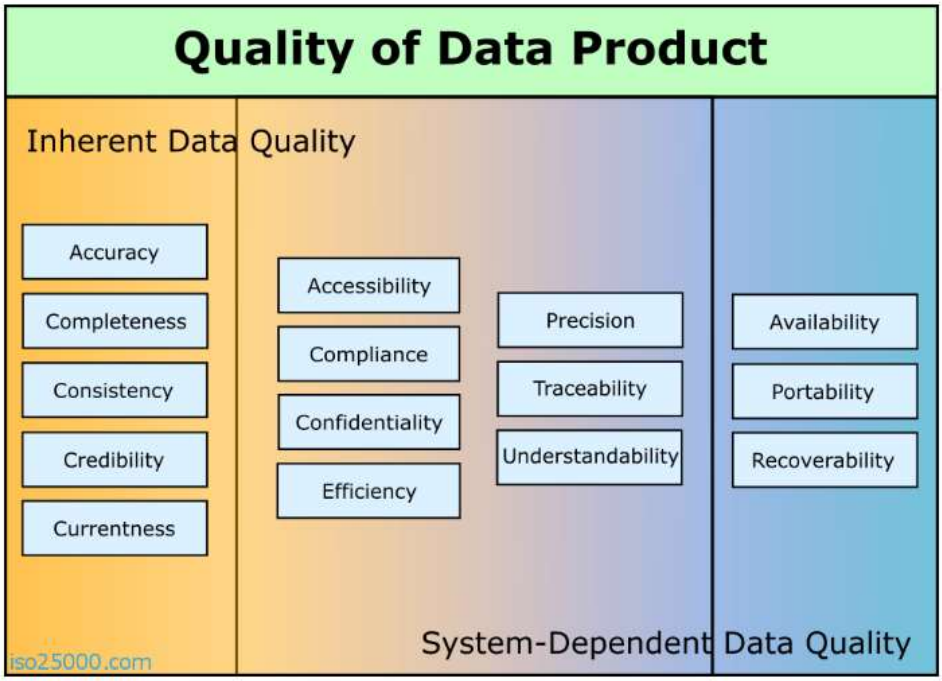

Figure 6 Data Quality characteristics main categories (ISO/IEC 25012).

European ITS Platform (EU EIP) has published a C-ITS Quality package for data and information quality in the context of C-ITS. The EU EIP report refers to the earlier mentioned ISO 9000:2015 standard on how quality is understood and proceeds to question on what does an "object" represent in the field of C-ITS quality. Higher level quality objects in the ITS standardisation include (EU EIP 2022):

- System Quality (e.g. availability of an entire technical system)
- Device Quality (e.g. reliability of devices within a system)
- Functional Quality (e.g. efficiency of an expected function of the system)
- Data Quality (e.g. accuracy of data used for a function)

Also, system and device quality are touched on. It is noted, that "for C-ITS services, also the quality of a single message may be important, as there are specific safety and efficiency implications related to each single message." (EU EIP 2022)

NAPCORE (National Access Point Coordination Organisation for Europe), that coordinates and harmonises European mobility data platforms, has established Quality Activity which includes a quality framework with key elements of

- quality criteria, sometimes also called quality indicators, metrics or parameters,
- quality levels which describe (minimum) requirements to be met for each quality criterion, and
- recommendations how to assess these criteria and levels.

The NAPCORE works in collaboration with parallel actions of TISA, U.S. Department of Transportation and C-Roads Platform. (NAPCORE Quality 2025)

4 Responsibility for data accuracy

Data accuracy and quality in general are essential with regard to the impacts of the data via the services utilising the data – the better the quality is, the more the users are trusting on it (having learned that the quality is good) and are also willing to use it providing the benefits aimed for by the service provider; and to the contrary, poor service quality can even have negative impacts on user benefits. (Laine et al. 2021 in EU EIP 4.1)

Poor data quality and accuracy with regard to user expectations can contribute to, for instance, road accidents, transport chain delays and unfortunate user decisions, for which the service provider and/or the data provider could be regarded to be responsible for. Such cases could lead to financial and image-related losses to the parties regarded as liable.

In this report responsibility for data accuracy is viewed from the legal and ethical perspective. This chapter discusses the first mentioned and the following chapter 5 the latter. The relationship between legal and ethical use of data is also discussed in chapter 5.

The following framework with five elements in the corresponding chapters were reviewed to evaluate road operator legal responsibility to ensure that data is accurate, and the accountability when inaccurate data is sent:

1. European legislation
2. Member States national legislation
3. Member States and authorities' contractual agreements
4. Navigation technology and traffic information related accidents – responsibility and legal consequences
5. Authorities and industry views on data usage and responsibilities

4.1 European legal framework

This chapter reviews the European legal framework related to Cooperative Intelligent Transport Systems (C-ITS) and Intelligent Transport Systems (ITS). Aim is to review Member states, national road operators and public authorities' C-ITS and ITS deployment responsibilities and references to data accuracy and quality.

European Parliamentary Research Service (EPRS) briefs according to the Lisbon treaty's hierarchy of sources of EU law (Figure 7): "legislative acts (author's note: such as an EU directive) come directly after the Treaties (including the Charter of Fundamental Rights) and the general principles of EU law. Legislative acts stand above any other (non-legislative acts) of the EU institutions, agencies, and bodies" (European Parliamentary Research Service, EPRS). These laws are referred in the following chapters.

Figure 7 Hierarchy of sources of EU law. (European Parliamentary Research Service, EPRS)

European Union regulations are applicable throughout the Member States as introduced in the beginning of the chapter. The delegated acts are legally binding acts, directly applicable and therefore not be transposed into national legislation. With delegated acts the Commission may supplement or amend non-essential parts of EU legislative act. (European Commission Types of EU law, EU Monitor)

Unlike delegated acts, the EU Directives are not directly applicable in the Member States but require national laws to incorporate their rules into national legislation. Member States are allowed to decide the form and means of national legislation. The Member States take part in the European Union legislative process, including commenting and voting. Directives specify by which deadline the Member States must adopt national measures, which is then also notified to the European Commission who examines and ensures the transposed law. (EUR-Lex Transposition, European Parliament legislative procedure)

National legislation is adopted in each of the Member States. The national legislation, with safety related roles and responsibilities clearly set, often includes legally binding regulation that impacts C-ITS and ITS data and information exchange. The national regulation can for example include road operators' tasks and responsibilities related to traffic control and management, which furthermore may relate to responsibilities on data accuracy and quality.

The government has the main national responsibility for the provision of safe digital and physical road infrastructure as well as safe operation of the road network. The government fulfils this obligation through the national road operator. (PIARC Road Safety Manual)

4.1.1 Directive of Intelligent Transport Systems

The European Union council adopted a new revised framework for the deployment of Intelligent Transport Systems (ITS) (2023/2661) in November 2023. The revision updated the previous ITS Directive 2010/40/EU. The framework directive supports coordinated use of Intelligent Transport Systems (ITS) across the Union Member States borders.

The directive applies to ITS applications and services and provides development actions for specifications, and when necessary, standards, in the following priority areas (Directive 2023/2661, Article 2, paragraph 1, Annex I):

(a) Priority area I: Information and mobility ITS services.
(b) Priority area II: Travel, transport and traffic management ITS services.

(c) Priority area III: Road safety and security ITS services.
(d) Priority area IV: ITS services for cooperative, connected and automated mobility.

Within the priority areas the Commission has adopted following priority actions: a) multimodal travel information services, b) real-time traffic information services, c) road safety related minimum universal traffic information, d) eCall, e) information services for safe and secure parking places and e) reservation services for safe and secure parking places for trucks and commercial vehicles.

The main difference between the ITS Directive (2010/40/EU) and the latest revised Directive in 2023 comes from the revision requirement for Member States to ensure that where the underlying information already exists, data are made available for geographical coverage for each data type defined in the Directive. The Directive sets further dates when the data is to be made available via a national access point. The Directive in 2010 required Member States to ensure that the specifications adopted by the Commission were applied to ITS applications and services, when these are deployed.

Information in scope of the Directive, referred as 'underlying information', can be found from the Directive's Annex III that lists considered data types as presented below in Table 2. Analysis of the data type subcategories and relevance for C-ITS services and road operators is also included in the table. The underlying information is defined with reference to road operators' (or road authority) responsibilities as follow in the Article 4 (2023/2661):

> *"(25) "underlying information" means information within the scope of this Directive that has been determined to be relevant for informing road and ITS users, in particular by road authorities where they are responsible for such information."*

Table 2 Analysis of the Directive of Intelligent Transport Systems (ITS) data type subcategories relevance for C-ITS services.

Data type category	Analysis of data type subcategories relevance for C-ITS services
1. Data relating to the provision of EU-wide road traffic information and navigation services (as referred to in Annex I, Priority area I, paragraphs 1.2, 1.3): **1.1. Category: Static and dynamic traffic regulations, where applicable, concerning:** **1.2. Types of data on the state of the network:**	1.1 Static and dynamic traffic regulations such as speed limits can be communicated (I2V) to road users via In-Vehicle Signage (IVS) service Traffic Signs use case (IVS-TS). (C-Roads TF2) 1.2 Types of data on the state of the network includes road and lane closures as well as roadworks, which are included in the C-Roads specifications and have high relevance for road operators.
2. Data relating to information and reservation services for safe and secure parking places for trucks and commercial vehicles (as referred to in Annex I, Priority area III, paragraph 3.2):	The C-Roads specifications include In-Vehicle Signage service Free Text (IVS-FT) use case.
3. Data on detected road safety-related events or conditions relating to road-safety-related minimum universal traffic information (as referred to in Annex I, Priority area III, paragraph 3.3):	Safety Related Traffic Information is highly relevant for C-ITS services and available in C-Roads specifications, including for example temporary slippery road, obstacles on the road, accident areas and exceptional weather conditions.

4. Static multimodal traffic data for EU-wide multimodal travel information services (as referred to in Annex I, Priority area I, paragraphs 1.1 and 1.3):	Multimodal travel data is not at the moment of writing this study available via C-ITS services, e.g. location of identified access nodes and information on accessibility of access nodes.

Requirements are set for specifications and standards that belong to the priority areas in the Directive Annex I Priority Areas. The priority area IV "ITS services for cooperative, connected and automated mobility" includes requirements for C-ITS information and warning services as well as C-ITS support to Cooperative Connected and Automated Mobility (CCAM).

Priority area III Road safety and security ITS services subcategory of 3.3 Specifications for road safety-related minimum universal traffic information states as follow (underlined sections in the text are considered important):

> *"The definition of minimum requirements, for road safety-related 'universal traffic information' provided, where possible, free of charge to all users, as well as their minimum content, based on:*
>
> *3.3.1. the availability and accessibility of accurate data on safety-related events and conditions needed for safety-related traffic information and incident management services"*

Priority areas I and II subcategories, that are related to C-ITS, 1.2 EU-wide road traffic information and navigation services, 2.1 traffic and incident management services and 2.2 mobility management services include the following:

> *"the timely updating of available… [Author's note: road and traffic data… real-time traffic information…]"*

Security credential management system for the EU C-ITS and specifications for the priority area "IV ITS services for cooperative, connected and automated mobility'" is adopted by the Commission who will cover the EU CCMS and included roles (Article 10). **Personal data** processing such as location data is also required to be carried out in accordance with European Union law of personal data and privacy as stated in the recital 23.

Member state responsibilities in addition to ensuring the underlying information already existing data is made available, include to ensure ITS services specified in the Directive 2023/2661 are deployed according to set coverage and dates. These ITS services are defined as road safety-related minimum universal traffic information, or in short Safety Related Traffic Information (SRTI) services.

4.1.2 Delegated acts of the ITS Directive priority areas

According to the ITS Directive the Commission may adopt delegated acts. Delegated acts can cover no more than one priority area and be adopted for each of the priority actions. Among the ITS Directive priority areas (see previous chapter) adopted delegated acts the following were seen relevant for this study when evaluating data accuracy and responsibilities (European Commission Mobility and Transport):

- Commission Delegated Regulation (EU) No 886/2013 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to data and procedures for the provision, where possible, of road safety-related minimum universal traffic information free of charge to users.
- Commission Delegated Regulation (EU) 2022/670 of 2 February 2022 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to

the provision of EU-wide real-time traffic information services. (repealing the proceeding Commission Delegated Regulation (EU) No 962/2015).

Real-time traffic information (RTTI) (EU) 2022/670 delegated act will repeal the Delegated Regulation (EU) 2015/962 starting from 2025. The RTTI Act aims to establish "specifications necessary in order to ensure the accessibility, exchange, re-use and update of data by data holders and data users for the provision of EU-wide real-time traffic information services, and to ensure that these services are accurate and available across borders to end-users." *Real-time traffic information* is defined in the RTTI Act as "information derived from any data on the infrastructure, data on regulations and restrictions, data on the state of the network and data on the real-time use of the network, or the combination thereof."

The recitals 16 and 21 in the RTTI Act state as follow regarding road operators et al. responsibilities and data quality. These recitals are later further reflected in the regulation's articles (<u>underlined</u> sections in the text are considered important):

> *(16) "…road authorities, road operators, holders of in-vehicle generated data, recharging and refuelling-related stakeholders, tolling operators and real-time traffic information service providers <u>should make the data, corresponding metadata and information on the quality of the data discoverable and accessible</u> to other road authorities, road operators, recharging and refuelling-related stakeholders, tolling operators, real-time traffic information service providers, digital map producers via the national or common access point."*
>
> *(21) "Member States and ITS stakeholders should be encouraged to <u>cooperate to agree on common definitions of data quality with a view to use common data quality indicators</u> throughout the traffic data value chain, such as the completeness, accuracy and up-to-dateness of the data, the acquisition method and location referencing method used, as well as quality checks applied. They should also be encouraged to work further to establish associated methods of quality measurement and monitoring of the different data types. Member States should be encouraged to share with each other their knowledge, experience and best practices in this field in the on-going and future coordination projects."*

The RTTI act covers following data type categories:

1) The types of data on infrastructure
2) The crucial types of data on regulations and restrictions
3) Other types of data on regulations and restrictions
4) The crucial types of data on the state of the network
5) Other types of data on the state of the network
6) The types of data on the real-time use of the network

Member state responsibilities include setting up a national access point to offer a single point of access for data users, including data updates, provided by the data holders. The RTTI act continues by defining accessibility, exchange and re-use of data for each of the data type categories to facilitate the provision of real-time traffic information services. The data is given following conditions for each of the data type categories, here given an example of Article 5 paragraph 2:

> *2. The data referred to in paragraph 1 and the corresponding metadata including <u>information on the quality</u> thereof shall be accessible for exchange and re-use by any data user within the Union:*
>
> *(a) on a non-discriminatory basis;*

> *(b) following minimum quality requirements that Member States shall agree upon in cooperation with relevant stakeholders;*
>
> *(c) within a time-frame fitting to the reliable and effective use of the data to create real-time traffic information;*
>
> *(d) via the national or common access point referred to in Article 3.*

The following paragraph 3 regarding data on infrastructure, regulations and restrictions and state of the network also mentions as follow:

> *3. Data users using the data referred to in paragraph 1 and data holders shall collaborate in order to ensure that any inaccuracies related to the data are signalled without delay to the data holder from which the data originates.*

The RTTI act Articles 8–11 include requirements of updating each of the data type categories. The updates are required to concern as a minimum the following parameters which are here shortened as a summary:

(a) the type of data
(b) the location of the condition
(c) the type of update (modification, insertion or deletion)
(d) the description of the update
(e) the date on which the data has been updated
(f) the date and time
(g) the quality of the data update as defined in quality requirements that Member States shall agree upon in cooperation with relevant stakeholders.

Article 12 Assessment of compliance paragraph 2 (a) states that the Member States may request from any data holders and data users a description of the data, digital map or real-time traffic information services they provide as well as the information on the quality thereof and the conditions of re-use of these data. This information can be used to assess the compliance.

Article 13 states that Member states shall provide Commission information about the geographical scope of the data accessible via the NAP, changes to the primary road network and to the data content of real-time traffic information services and their quality, including the criteria used to define this quality and the means used to monitor it.

As a summary, the minimum quality requirements and data updates (having an impact to data quality) are referred in the RTTI act, although not specified by technical details, and instead stated to be accomplished and agreed in Member State cooperation with relevant stakeholders. The collaboration referred in the RTTI delegated act has been further established by the Member States in the NAPCORE project building on the earlier work in the area by EU EIP.

NAPCORE (The National Access Point Coordination Organisation for Europe) is the European Union co-funded organisation to coordinate and harmonise European mobility data platforms, i.e., National Access Points (NAP) setup, data access interfaces and data formats as well as standards. (NAPCORE)

Safety Related Traffic Information (SRTI) (EU) 886/2013 establishes the specifications for the deployment of and operational use of road safety-related minimum universal traffic information free of charge to users on a European Union level. The Act applies also to the provision of road safety-related traffic information services on the trans-European road network.

Road safety-related minimum universal traffic information means according to the Act “any

extracted, aggregated and processed road safety-related traffic data, offered by public and/or private road operators and/or service providers to end users through any delivery channels." List of SRTI events or conditions that are covered by the SRTI act are presented in the Article 3 as follows:

(a) temporary slippery road;
(b) animal, people, obstacles, debris on the road;
(c) unprotected accident area;
(d) short-term road works;
(e) reduced visibility;
(f) wrong-way driver;
(g) unmanaged blockage of a road;
(h) exceptional weather conditions.

Member states, public and private road operators as well as service providers are set requirements and responsibilities in the SRTI act that include the followings summarised and highlighted here from data accuracy and responsibility perspective:

- *Public and private*: items that the information provided shall include are location, category of event or condition and driving behaviour advice, where appropriate. Removal of the information if it ceases to subsist or modification if the event or condition changes. (Article 4)
- *Member States*: designate sections on the trans-European road network where traffic and safety conditions require the deployment of the SRTI service. (Article 5)
- *Public and private*: set up or use the means to detect events or identify conditions and shall collect the relevant road safety-related traffic data. (Article 6)
- *Public and private*: share and exchange the SRTI data/information they collect being accessibly by any user via NAP in DATEX II (CEN/TS 16157) format or any fully compatible and interoperable with DATEX II. Requirements include timely provision of the information service and timely renewal and quality of data. (Article 7)
- *Public and private*: SRTI to widest reach of end users free of charge prior to any other non-safety related traffic information. Public and private entities shall collaborate to harmonise the presentation of the content of the information provided to end users and inform of existence of the information service and its coverage. (Article 8)
- *Member states*: national body to assess and randomly inspect the public and private fulfilled requirements in Articles 3 to 8. (Article 9)
- *Public and private*: submit or update a declaration of compliance according to requirements to a national body. (Article 9)

As a summary, the SRTI delegated act sets several requirements for the Member States and public and private road operators to establish SRTI road sections, information and services. Also, means to detect events or identify conditions as well as share the SRTI information via NAP free of charge to wide reach of end users. Timely SRTI provision, renewal and data quality are also needed to be ensured.

4.1.3 Other ITS and C-ITS relevant European legislation

The legislation reviewed in this study is not complete and many other European and national legislations can be considered being related to C-ITS (e.g. see Kotilainen et al. 2024 study on C-ITS roles and legislation in Europe and Finland). Nevertheless, as the scope of the study limits to ITS and C-ITS data accuracy responsibility, the following European legislation was identified having an impact and further introduced in this chapter:

- C-ITS specific legislation (draft delegated act in 2019)
- Protection of personal data
- Security
- Open data
- Liability for defective products

A C-ITS delegated act was drafted between 2017 and 2019 by the European Commission. The C-ITS act C/2019/1789 was published in 2019, but it was objected against by the Council of the European Union. Although there was no C-ITS specific legislation in force in Europe at the moment of writing this study, the European Commission may continue its draft proposal and adopt delegated acts in according to the ITS Directive (2023).

Due to the importance for the road operator's responsibility of data accuracy, the draft C-ITS delegated act (2019) content is here highlighting some of the relevant parts in consideration of the study topics. First, the Article 1 paragraph 1 subject matter and scope:

> *This Regulation establishes specifications necessary to ensure compatibility, interoperability and continuity in the deployment and operational use of Union-wide CITS services based on trusted and secure communication.*
>
> *It lays down how vehicle-vehicle, vehicle-infrastructure and infrastructure-infrastructure communication is to be conducted by means of C-ITS stations and how C-ITS stations are to be placed on the market and put in service, to enable the provision of C-ITS services to ITS users.*

Paragraph 2 continues, that the regulation applies to all C-ITS stations, i.e., hardware and software components to exchange trusted C-ITS messages in C-ITS services, in the field of transport. Paragraph 3 further states, that Member States shall designate the part of their transport network infrastructure that is equipped with C-ITS stations. Therefore, the draft C-ITS act would have applied to C-ITS stations if Member States had deployed them in part of their road network.

The draft C-ITS act continues in separate chapters to sets requirements for the C-ITS stations, placing the C-ITS stations on the market, putting in service and operation of C-ITS stations, security an implementation (not put in force) as well as final provisions. The Annex I contain the service profiles for the C-ITS priority services and their required information quality value in the DENM data element.

Protection of personal data is guaranteed in the European Union fundamental rights: Everyone has the right to the protection of personal data concerning him or her (EU Charter of Fundamental Rights). The European Commission Draft C-ITS act (C/2019/1789) states that processing of personal data must be carried out in accordance with the EU law in particular the General Data Protection Regulation (GDPR) and the e-Privacy Directive Data privacy legislation in Europe. The previously mentioned legislation and other policies related to personal data protection are studied more in detail in the TIARA project's Work Package 4 Privacy in C-ITS Applications deliverable.

Security architecture legislation, related to the ITS Directive (2023) requirements, supported by a public key infrastructure (PKI) is required by the C-ITS services to exchange trusted and secured data. The European security framework for trusted and secure C-ITS communication, using Public Key Infrastructure (PKI), the European Union (EU) C-ITS Security Credential Management System (EU CCMS) is introduced and studied more in detail in the TIARA project's Work Package 2 PKI Guidance development and its deliverables.

Open data and the re-use of public sector information has been regulated in the Directive (EU) 2019/1024 (European Union 2019), i.e., successor of Directives 2003/98/EC and 2013/37/EU.

The Directive aims to promote the use of open data and stimulate innovation in the market. It sets out the minimum rules governing the re-use and practical arrangements for facilitating the re-use of such as documents and research data of public sector bodies of the Member States. The Directive states that any use of the documents shall be non-discriminatory and fair trading as well as transparent. Use of standard license that are not subject to conditions is encouraged, i.e., set of predefined re-use conditions in a digital format, preferably compatible with standardised public licences available online.

Liability for defective products has been introduced in the Directive (EU) 2024/2853. The Directive applies to products placed on the market or put into service after 9 December 2026. The scope does not apply to free and open-source software that is developed or supplied outside the course of a commercial activity. The burden of proof is for the claimant who is required to prove the defectiveness of the product, the damage suffered and the causal link between that defectiveness and that damage.

The directive updates the EU's liability rules to cover new technologies to protect victims and provide legal certainty for economic operators. The directive covers individual persons death, injury, property and destruction or corruption of data; companies are not covered but could be included in national legislations. (Liability for defective products–European Commission n.d.)

From the ITS and C-ITS service as well as data accuracy responsibility perspective it is noticeable, that the directive covers all types of software including applications, operating systems and AI-systems. The Commission will provide an EU database where decision on judgements of product liability cases are made accessible.

The Directive mentions the following in recital 17 and provides an example on traffic data navigation system being an integrated or interconnected digital service having a strict (no-fault) liability if the vehicle manufacturer or service provider of the navigation system controls the service:

> *"(17) It is becoming increasingly common for digital services to be integrated into, or inter-connected with, a product in such a way that the absence of the service would prevent the product from performing one of its functions. While this Directive should not apply to services as such, it is necessary to extend no-fault liability to such integrated or inter-connected digital services as they determine the safety of the product just as much as physical or digital components. Those related services should be considered components of the product into which they are integrated or with which they are inter-connected where they are within the control of the manufacturer of that product. Examples of related services include the continuous supply of traffic data in a navigation system, …"*

4.2 Member States and authorities' contractual agreements and incentives

Terms of Service (ToS) are legally binding agreement between a road operator (consumer) and service provider for a use of service or product. ToS sets the limits on what the road operator can do (or cannot) when using the service. ToS can form the basic rules of legal liabilities that also concerns data quality related matters such as responsibilities.

Service Level Agreements (SLAs) are more specific contracts defining level of service or performance. SLA is signed between the road operators and traffic information service providers to agree for example on the quality of data to be delivered. These contracts are not disclosed due to being private between the contract parties. Although individual contracts are not available, these contracts provide one possible example of a solution where public and private stakeholders agree on the roles and responsibilities including data accuracy and

quality.

Open data offered by the road operators can also include terms of use and statements of no liability for specific types of data use. As supported in the Open Data Directive, the road operator terms of use might include standard license such as Creative Commons, which can give the user right to copy, modify and further distribute the data in original or modified form. Meanwhile, warranties or liability for the material can be excluded. (Creative Commons 4.0)

Data for Road Safety is the name selected for the European Safety Related Traffic Information (SRTI) Ecosystem. The Ecosystem can be seen as a practical platform for the implementation of the SRTI delegated act 886/2013. The Ecosystem partners include OEMs, service providers and Member States. The exchange of information between the Ecosystem parties is done under the terms and conditions of the Multi Party Agreement which creates a trust domain for the exchange.

The SRTI content is exchanged within the Ecosystem in-kind on the basis of reciprocity, i.e., mutual benefit of SRTI between the parties without financial compensation. Therefore, the agreement fulfils the delegated act requirement to provide SRTI free of charge to the end user. The agreement sets requirements for the provision and use of content. The rights of the States and/or public authorities to use SRTI content are different from those of the private industry parties.

The Traveller Information Services Association (TISA) has introduced a five-star quality rating for real-time traffic information (RTTI), such as Road Works data, that includes minimum quality requirements for the road operator data. By filling the minimum requirement of data quality (three stars), road operator data would be mostly likely used by the service providers. When road operators' data gets used, road safety and traffic flow can be improved, therefore giving the road operators an incentive to improve their data quality. (TISA Draft proposal 2024)

4.3 Navigation technology and traffic information related accidents – responsibility and legal consequences

Catastrophic incidents associated with GPS devices and other personal navigation technologies, which use traffic information, have been given a nickname "Death by GPS". In study by Lin et al. (2017) it was concluded that missing road characteristics data contributed to over 24% of Death by GPS incidents. The study recommendations outline "space usage rule" mapping, incorporating weather information in routing, and improving visual and audio instructions in complex situations. The study includes 158 detailed news reports of unique catastrophic incidents associated with navigation technologies. Distribution of the seriousness of incidents presented in the study can be found in the table below with reference to legal consequences of medium seriousness accidents. (Lin et al. 2017)

Table 3 Distribution of the seriousness of incidents. (Lin et al. 2017)

Seriousness of Incidents	#	%
Major (deaths)	44	28%
Major (injuries)	23	15%
Medium (e.g. property damage, legal consequences)	52	33%
Low (e.g. significant inconvenience)	39	25%

Lin et al. (2017) suggest that there can be a survivorship bias in accidents related to navigation technologies, which in this study also are considered accidents closely related to the traffic information quality. Survivorship bias comes when we receive information only from those accidents that were not fatal and reported, i.e. the driver and occupants survived, but we don't receive information about the use of navigation technologies from those accidents where there were fatalities, i.e. no one was left to report on what happened and therefore responsibility of the accident cannot be determined.

Posey (2023) in his study "The final destination: Incorporating 'Death by GPS' into forensic and legal sciences", argues that a there is a growing problem of motorists who set out for travel following directions from their GPS device and never return. The study presents case examples of GPS related fatalities with variables such as out-of-date maps, unfamiliarity with surroundings areas and distracted driving. The study suggests forensic science research that may benefit from the creation of a technology autopsy and criminal justice to research examine negligent homicide policies related to GPS. These recommendations could lead to further studies of responsibilities and legal case decisions in future.

Both the Lin et al. (2017) and Posey (2023) mention that either the accident reports, witnesses of the accidents, or the evaluator of these incidents, are tempted to place responsibility of the accident on drivers, it is noted that the incidents are multilayered, from for example on cognitive, social and ethics perspective.

The interviews with road operators and industry representatives did not bring up **European cases** or traffic information legal case decisions or harm caused when using incorrect data leading to legal consequences. The main reason for this was considered to be the nature of the data, i.e., on what characteristics and purpose the data has been provided. Data provided was considered not being safety nor financially critical data to third parties, but rather data that was meant for informative uses only.

Road users may for example access information about the current traffic situation and information regarding road works. If the data would be incorrect, it would create inconvenience such as longer travel time to selected destination at worst, but since the data is provided for informative purposes only, legal consequences are not to be expected.

Weather information and especially detailed location information about slippery road conditions were given by one road operator as an example of data that are considered potentially risky to provide for the road user, and a potential legal issue. Road operator providing slippery road information in a large scale can cause drivers to expect the road not be slippery if such is not informed by the authorities. Slippery road conditions can depend on driver's personal preferences and experience on winter road driving as well as the tyres on the vehicle. Also, if vehicle manufacturers and traffic information service providers already provide such information with better accuracy (due to vehicle data), it might not be useful to compete. Previous studies have shown that there were no accidents in winter conditions where the driver would not have known that it could be slippery.

Wrongfully given audio directions from a sat-nav application led to a wrong-way driving on a major road in UK and a fatal crash in 2024. Reportedly other vehicles had performed similar manoeuvres in the same slip road where the driver drove wrong-way. Tech companies were warned by the coroner of the nav app risks and companies agreed to amend their audio prompts. The slip road was equipped by the UK National Highways with "no entry" sign and also put up signs telling drivers not to use sat nav. (BBC 2024)

Global cases outside of Europe can also shed light on possible issues that are not yet experienced in Europe or were not found during this study. The following cases are reported from the study's interviews and news articles.

When looking at outside of Europe, to United State of America, interviewees in the first TIARA

workshop (2024) discussed and raised examples of data sharing issues that are many ways opposed to the ones in Europe. In US the contracts can include many protection clauses that hinder data sharing. Good data sources can become unsustainable to use due to conditions set in the contracts, i.e., risk of being sued causes a need of lawyer resources and can scare away any interested data feed users. Therefore, even with a good data platform, the traffic information service providers, can struggle to build applications due to legal risks.

All over the world the wide use of navigation apps has led to drivers using residential or sensitive road sections (such as those passing hospitals or schools) not meant for nor containing safety measures targeting heavy through traffic (UC Berkeley 2019). In practice the only way to prevent this will be the implementation of road signage forbidding through traffic as the navigation apps will update the road connection properties with this item of an additional traffic rule to be complied to on the connection,

Cases of misleading or erroneous data and information can also lead to criminal liabilities. Google was sued due to guiding a driver to use a bridge that had been taken down years before leading to the driver's fatal injuries. Google had received several warnings of this false data issue but failed to correct their map data. (arsTECHNICA 2023)

In India a man drove a car to a deep drain and was killed in 2025. The driver was allegedly using a navigation app when the car plunged into the water. The locals notified that there were no road signs installed (Autoevolution 2025). Similar accident happened earlier in India where a car drove over an unfinished bridge with no warning signs; navigation app developer engineers were part of the police investigation, but charges unknown (Autoevolution 2024).

4.4 Authorities and industry views on data use and responsibilities

This chapter reviews feedback and comments received from the authorities and industry regarding data use and responsibilities. The methods were interviews, emails, and a workshop session. The feedback has been highlighted below as a bolded text to indicate main topic of the feedback.

4.4.1 Road operators' views

Evaluation of data quality and usage helps to act on the data quality that the authority is responsible for. Lack of feedback about the usage of the data feed from its users can in some cases make it difficult to assess the data quality. For example, data on TPEG (Transport Protocol Experts Group) traffic and travel information usage can be only obtained very generally in the form of how many countries or how many vehicles have used it, but not per country level information. The reason for this is the agreements that limit any publication about clients' names and data that is being used and its impact.

Terms of use and license agreements in most cases applied by the authorities and industry state that the content owners are not liable for flawed data and information provided are only recommendations for user's own decision-making process. For example, National Access Points (NAP) in the Member States, depending on the respective license agreements, may contain such license terms that content providers "shall ensure the quality and correctness of the data." The terms of use may not specify any liability of the content provider nor that the provided information may be used for information purposes only.

4.4.2 Traffic information service providers' views

Numerous global, regional, national and local traffic and traveller information service providers use road operator provided data as a basis for their services. Therefore, the traffic information service providers are not only the largest users of the road operator data, but also the ones

constantly working and analysing the data quality that the authorities provide.

European legislation requirements for data accuracy and quality were seen vague lacking concreteness. ITS directive was seen as the most important legislation together with delegated acts.

The latest revision of Real-time traffic information (RTTI) (EU) 2022/670 delegated act was the most mentioned one in the interviews.

TISA has promoted the five-star quality rating for real-time traffic information (RTTI) that includes minimum quality requirements for the road operator data as introduced in Chapter 4.2. One interviewed TISA member was hopeful that the proposed ratings, which have been done in collaboration in RTTI data quality workshops, would be successfully implemented and taken up by the Member States authorities. (TISA 2024)

NAPCORE has been working with the data quality but with quite limited resources.

Industry standards for assessing the quality of traffic information in the services for drivers such as QBench are followed.

Terms of service use applied by the traffic information service providers in their products include strong disclaimers of the nature of the data as it should be used for guidance support only and the driver remains in charge of following local regulations.

Open data quality was discussed during the workshop. Although many authorities provide good quality of traffic information, there are still several occasions where the traffic information service providers were not able to use public open data feeds due to poor quality. Free data can often have poor or inconsistent quality. The main reason for some the authorities' poor open data quality was estimated to be the lack of funding of government data operation. For those authorities struggling with data quality issues and insufficient funding, it was suggested even to have a charge for accessing their data feeds, if increased funding from the government is not received and if that results in a better quality of the data feed.

4.4.3 Workshop on data accuracy and road operator responsibilities

The TIARA project workshop arranged on 7th of May 2024 included a session on data accuracy and road operator responsibilities. Six participants (n=6) took part in the session. The participants represented public authority, private industry and research organisations. The research framework and the five elements reviewed in this chapter (European and national legislation, contractual agreements, case studies as well as public and private stakeholders' views) were introduced to the participants with related questions (APPENDIX 1). The feedback was qualitatively reviewed, and results included for relevant parts in the previous chapters. The following is a summary of the workshop results.

European legal framework literature findings were presented as hypotheses for the workshop participants. A question was raised by the participants, what role would the European Commission take in the future to specify data accuracy or quality or would such rather be left to the road operators and member states. The road operators and member states could also subcontract such activities to a data clearing house or third-party. Distinction might be needed for example between a Public Transport Operator's and private companies' data.

The delegated act of Safety Related Traffic Information (SRTI) was mentioned as setting requirements for the Member States and public and private road operators. It was questioned whether CCAM would require additional legislation regarding data accuracy, or whether it falls under the existing legislation. The revision of the Product Liability Directive also covers digital products, including software and AI systems. The Revised ITS Directive 2023/2661

does mandate on use of standard interfaces and DATEX II, but more details and for example minimum requirements are needed as they can have a large impact on implementation. It was questioned, how minimum standards and requirements would be then communicated to consumers, as they will likely rely on the data.

Member States national legislation and policies in some countries include policies and rules which advice data quality to be published by the authorities. Other national experiences referred to specific rules that apply on top of the regulation, which makes the authorities further enhance data quality, for example on location data. Even without specific policies, trust itself was seen as an important factor to enhance data accuracy or quality. Authorities further extend data quality rules requirements to subsidiaries and contractors. Also, before a specific legislation, the data quality requirements need to be understood as they can be very use case specific. For example, emission and speed limit regulations require studies to understand the requirements first. A further important question was raised on how the roles of road operators for data change vary across EU countries? This can affect data quality and responsibility, being part of the European legal framework collaboration between the Member States.

Member States and authorities' contractual agreements including Service Level Agreements were under development in some states. These business contracts concerning for example open data or even B2B2C, require a lot of preparation work which specific data teams can help to manage. Responsibilities need to be clearly defined in contracts or same cases in Terms of Reference (ToR). Contracts or ToRs can be made with for example with road maintenance contractors, which require clear definitions as a contractor might not be interest or aware on timely data updates. **Member States and authorities also have incentives**, which can include data quality ratings. It was questioned whom should assign the star ratings and how are they determined or controlled. Examples mentioned were the TISA (Traveller Information Services Association) and iRAP (the International Road Assessment Programme) star ratings. Also, applications should meet quality requirements of the specifications, e.g. accuracy, timely delivery.

Authorities and industry views on data usage and responsibilities included comments on data quality perspective and trust between the stakeholders. *First*, data quality can depend on the perspective of the user and whom you ask, for example some experiences where data provider was satisfied for the results of data quality, but data users dissatisfied. Data quality management can be an issue as the management requires continuous follow up and updates. Just opening or publishing data or once enhancing data quality might not be enough as constant management is needed, otherwise the data quality can decrease in time. *Secondly*, experience in the past shows that OEMs have had distrust of other data sources than their own. They main reason for distrust is the concern for safety. OEMs are aware of the quality of data provided by the sensors in their vehicles, and they know they can trust their device manufacturers' certified sensors. Bad data quality could in addition to accident liabilities have an impact on brand reputation. Meanwhile public authorities may lack or have lower grade safety certifications concerning their sensors and infrastructure, e.g., cameras. In such a case of lack of trust, to solve any legal responsibility issues, agreed standards or external trusted quality control could be a solution. It was also noted there being asymmetry of information need from OEMs and service providers to road operator data needs, i.e. not much need from the industry side.

Case studies and legal case decisions were discussed around three topics of liability and data quality knowledge, use cases dependency and available case examples. *First*, liability and responsibility when a data provider shares inaccurate data poses a question whether the provider knew about the poor data quality, and/or the possible inaccuracies and risk involved

with it and still decided to send the data. *Secondly*, data quality is dependent on the use case and sometimes it would be better to warn than not to warn the customers. For example, when sending traffic signal SPAT/MAP information and there is a delay in the system and application User Interface, and there is a doubt whether these could cause harm, there is a liability issue, and you would need to warn users about potential issues in real-time communication. Liability issues were highlighted when the current ADAS systems with driver in responsibility are shifting towards higher levels of automation. *Thirdly*, case examples could also be found from mobility data services and their quality control and experiences. One case example from Netherlands was introduced where a tunnel accident occurred when a contractor didn't update information timely which then led to an inaccurate traffic information causing the accident.

4.4.4 Meetings and interviews on data accuracy and road operator responsibilities

On 18 June 2014, a session at the PEB meeting in Ghent discussed the issues of data accuracy for road operators. The participants agreed that the information service providers are the key actors and users with regard to the data provided by the national road operators. They use the data from the road operators as reference for the data that they collect themselves or from other sources and likely have a good understanding of the data quality. If they find the quality sufficient, they will utilise it also when producing their traffic information feeds.

In the ethical perspective, it would be appropriate for the road operators as well as any other data provider to inform the data users about the quality of the data provided. TISA (2024) has therefore proposed a 5-star rating for real-time traffic and travel information. The rating would give the traffic information providers and National Access Point (NAP) providers sufficient knowledge of the data quality for decision making on whether to use the data or not. TISA recommends only use of data classified with three stars or more in the NAPs. (TISA 2024)

The road users also access and use the data and traffic information provided by the road operators. They decide whether to use the data/information or not. If it is not good enough, they will not use it. For them a star rating could be useful when first starting the use of a particular data or information feed.

The participants also concluded that the quality of data depends on information use cases. For example, safety critical use cases put more pressure on data quality as poor data leading to fatalities to injuries may have severe liability consequences.

Many road operators stated that they provide the data for information only, and that people should take this into account. The conclusion drawn by the participants was that this has no actual meaning for the road users. Hence, the road operators cannot escape from data quality related liabilities with a general statement of "information only". The road operators should give explicit information about the quality of the data that they provide as open data or traffic information, preferable at the point of use for the data/information. This in turn means that they should also realise the importance of data quality assurance and control processes and commit to setting up and maintaining such processes in a satisfactory manner. This point was also highlighted at the ITS World Congress in Dubai 2024, and its post-congress report. (ERTICO 2025).

4.5 Analysis of responsibility for data accuracy

The analysis of road operator responsibility on data accuracy included European legal framework of ITS directive and related legislation, member states national legislation, their contractual agreements, navigation and traffic information use cases and authorities as well as industry views.

Regarding the European legislative framework for Intelligent Transport Systems (ITS) in the ITS Directive (2023/2661), the requirements state that underlying information already exists, data are made available for geographical coverage for each data type defined in the Directive. These ITS data types such as roadworks or weather-related events can also be exchanged by C-ITS. Requirements for the standards and specifications include C-ITS and safety-related traffic information, mentioned previously as examples and which of many C-ITS services are, where the latter includes minimum requirements for the availability and accessibility of accurate data.

No direct technical requirements outside of required data formats (DATEX II, etc.) related to ITS or C-ITS data accuracy nor quality in European legislation was identified. Member States are still required by legislation to set up National Access Point to make the data available and communicate inaccuracies in collaboration with the stakeholders, provide parameters of the quality of the data update, and follow minimum quality requirements that are agreed in cooperation with relevant stakeholders (RTTI 2022/670).

The ITS framework directive with the above-mentioned requirements are further implemented in the European Member States, where implementation depends on legislation and policies, by the road operator or National Road Authority (NRA).

When a road operator deploys C-ITS services it should follow the applicable standards and common European harmonised specifications to achieve cross-border interoperability (C-Roads); these standards and specifications include or may include in the future minimum requirements for the data accuracy/quality. Examples of European Member States and industry collaborative work on harmonisation of data quality are the EU EIP and NAPCORE projects, which have provided frameworks and a collaborative platform for the work.

Other ITS and C-ITS related European legislation also sets responsibilities on protection of personal data, security and open data. One to mention especially is the liability for defective products Directive (EU) 2024/2853. According to the recital example in the Directive it is here analysed that a software product such as navigation systems (a product) with faulty traffic data can be considered responsible of an accident if it is seen as an integrated or interconnected digital service with manufacturer or service provider being in control of the system. Responsibility for road operator may come not only from a service they provide, but possibly on the quality of data if it considered as a “data service or product”. For example, digital traffic rules and regulations: if a navigation manufacturer receives a faulty digital regulation information from the road operator NAP or cloud service, the responsibility and fault of the “data product” could be questioned. Future jurisdictions and judgements can provide more insights as the Commission is opening a service to follow them.

Member States and road operators’ contractual agreements, such as Terms of Service (ToR) or Service Level Agreements (SLA) also include legal agreements and further responsibilities that need to be followed. These agreements can also be in an ecosystem level, such as Data for Road Safety ecosystem or TISA 5-star rating, where public and private partners agree together on data quality. These ecosystem collaborations also follow the ITS directive requirements on safety related and real-time traffic information.

Finally, case studies on navigation technology and traffic information related accidents present a growing concern on their impact on traffic safety. More studies and possible jurisdictions on accident investigations, such as technology autopsy and criminal justice, could be followed in

future to help determine the responsibility of the service and data providers. While biases may be presented on the accident data (only survivors of accidents provide input), it is important and ethical for road operator to support work on data quality and its legal responsibility.

5 Ethical use of data

This chapter introduces data ethics including its research background, definitions and areas of research. Views from industries and lessons learnt on the ethical use of data are reviewed by analysing industries most closely related to ITS and C-ITS but also other industries to gain wider perspective.

Ethics in digital world can be a broad concept with overlap between different areas of ethical questions and research. For example, the Ethics4EU project mapped European values for ethics in digital technology and found 50 values for teaching digital ethics to computer science students. The project classified the values to eight categories on digital ethics topics, i.e. foundations of Digital Ethics (Ethics4EU 2022):

- Digital Ethics Values
- Data Ethics
- AI Ethics
- Ethics for Pervasive Computing, Privacy and Surveillance
- Social Media Ethics
- The Relationship between Digital Ethics, Digital Regulations and Digital Governance
- Professional Ethics

This chapter mainly focus on data ethics but also evaluates wider perspectives on the topics under discussion, e.g. professional ethics that provide guidance to professionals building the data services.

5.1 Relationship between law and ethics

The relationship between law and ethics, the first mentioned discussed in the previous chapter 4, is strong but they are quite distinct. Regulation and legal standards are established by governmental bodies and enforceable by the legal system. Meanwhile ethical standards provide guidelines for societal norms and values. (University of Pittsburgh 2024)

One way to describe the relation between legal standards and ethical standards is to compare the standards requirements and level of impact to behaviour. Legal standards prescribed by law can provide minimum acceptable behaviour while ethical standards go beyond this with higher levels of responsibility and accountability (University of Pittsburgh 2024). In other words, decision on data usage may comply with law and regulations but still be unethical by harming environment or society.

It is also noted that laws for the specific technology may not exists. Laws are also technology agnostic to ensure compliance with future technologies. This can increase the need for data ethic framework in the organisation to maintain and protect public trust. (UK Finance 2025)

Therefore, by following the forementioned relation of laws and ethical standards, the European legislation mentioned in the earlier chapters of this report can be considered being “minimum acceptable behaviour” for ethical use of data in C-ITS and ITS services.

Study by Eke & Stahl (2024) have done an analysis of European data regulations and policies in relation to ethics in the governance of data and digital technology. The study states that “current EU data governance policy landscape can be read from an ethical perspective as being grounded in ethical thinking, typically expressed in terms of human rights.”

Protection of personal data from threats to privacy and data protection is one of the core topics in C-ITS that includes the GDPR legislation mentioned earlier in the study. The

European Data Protection Supervisor has worked closely also with ethical questions by initiating discussion on relation between ethics and the law when phasing new technologies (European Data Protection Supervisor), and initiated a call upon European and global community stating (European Data Protection Supervisor):

> *"…reflect on rights and values in data-driven life and aims to encourage a proactive and forward-looking engagement with the issue. This includes stimulating a public debate on how digital ethics can serve to strengthen core data protection principles beyond legal compliance... Ethics comes before, during and after the law."*

The European Data Governance Act (DGA) aims to increase trust in data sharing, strengthen mechanisms to increase data availability and overcome technical obstacles to the reuse of data. Key pilar of this act is the European strategy for data (COM/2020/66). (European Union 2022/868)

Artificial Intelligence (AI) EU guidelines have also been published after the call from the European Parliament to update and complement the existing Union legal framework with guiding ethical principles. Human centric approach to AI has been carved with respect to European values. (Madiega 2019)

5.2 Introduction to data ethics

Data usage has grown each decade which have increased the reliance on the services and products that use the data to convey information not only about physical objects, but also personal and private information of individuals. Algorithms and Artificial Intelligence can be used to explore this data which may include concerns on designer responsibility, data privacy and fairness of use.

Ethics involves learning what is right or wrong, and doing the right thing where the ethical dilemmas arise. Moral values guide how we behave, for example fairness and responsibility, and moral and ethical principles are the statements how these values are applied. (Krishnamurthy 2011)

The general definition of ethics includes the analysis of conduct that can cause benefit or harm to other people. Ethical theories enable one to make persuasive, logical and reasoned arguments based on the principles stated by the ethical theory. Examples of ethical theories that have been applied to data ethics include Kantianism, Utilitarianism, Social Contract Theory and Virtue Ethics. Kantianism is what we ought to do, Utilitarianism examines right or wrong based on the consequences of an act or rule, Social Contract Theory person's moral and/or political obligations that are dependent upon a contract or agreement with the society and virtue ethics about virtues and moral character. (Herschel & Miori 2017)

Foundation of data ethics can be found in the fields of computer and information ethics that have studied the challenges of digital technologies. At first a human-centric approach was introduced in the field of computer and information ethics, i.e. looking at the ethical problems posed by dissemination of computers and responsibilities designers and users. Then the level of abstraction shifted to the computer-centric, i.e., tools that could shape social dynamics and environments surrounding us. This then shifted to moral dimensions and then focused to content, information that is created, processed and shared, i.e. macroethical approach to address the whole cycle of information. (Floridi & Taddeo 2016)

Aim of data ethics from one perspective is defined in the UK government Data Ethics Framework (2020) as follows:

> *"The aim of data ethics is to promote responsible and sustainable use of data for the benefit of people and society and ensure that knowledge obtained through data*

is not used against the legitimate interests of an individual or group while identifying and promoting standards, values and responsibilities that allow us to judge whether decisions or actions are appropriate, 'right', or 'good'."

Definition of data ethics in the UK Data Ethics Framework (2020) refers to the Floridi & Taddeo (2016), where data ethics is seen as a branch of ethics that studies and evaluates moral problems that formulate and support morally good solutions on three related areas: data, algorithms and corresponding practices. The mentioned three research areas are presented in the Table 4 below with included topics, ethical problems and related key issues. As noted by the researchers, the research areas do not lie solely on a single axis as issues addressed in data privacy will also link for example with practices of consent and responsibilities. Therefore, it is emphasized that all three areas (or axes) should be researched together.

Table 4 Three related areas of data ethics research as introduced and adapted from Floridi & Taddeo (2016).

Data ethics research area (axes)	Topics included	Ethical problems	Related key issues
Data	Generation, recording, curation, processing, dissemination, sharing and use of data.	Re-identification of individuals, data mining, use of large datasets e.g. linking, identification of types of individuals from group and discrimination (privacy).	Trust, transparency and lack of public awareness
Algorithms	Artificial intelligence, artificial agents, machine learning and robots.	Complexity and autonomy of algorithms, moral responsibility of designer and data scientist	Ethical design and auditing of algorithms requirements and assessment of outcomes
Practices	Responsible innovation, programming, hacking, professional code and ethics as well as deontology.	Responsibilities and liabilities of people and organisations in charge with goal to define an ethical framework.	Consent, privacy and secondary use of data.

Open Data Institute (ODI) defines data ethics as "A branch of ethics that evaluates data practices with the potential to adversely impact on people and society – in data collection, sharing and use". ODI mentions that data ethics should be addressed at all stages of stewarding data, creating information from the data and deciding what to do.

Data ethics ask the question "Is this the right thing to do?" and "Can we do better?" while encompassing moral obligations of gathering, protecting, and using personally identifiable information and how it affects individuals as defined by Tingley & Cote (2021).

A further topic related to data ethics is big data ethics which refers to the ethics of the use of large and diverse datasets of different variety as well as big volume and more velocity. Ethical issues related to big data include topics such as data mining and predictions with unexpected insights, informational reuse and unauthorized data as well as data privacy. (Herschel & Miori 2017)

Data ethics also encompass legislation such as data protection law, that is used in the decision-making process to protect for example individuals' rights and appropriate usage of new technologies. Data protection and privacy with related legislation and issues is reviewed and discussed further in the TIARA project Work Package 4 Privacy results.

5.3 Lessons on ethical use of data

This chapter reviews private industry and public sector reports on ethical use of data. Private industry sectors were partly selected based on the C-ITS actors presented in the study, but also other industries were selected to gain wider perspective of examples.

5.3.1 Connected and Automated Vehicles data ethics

Aim of this chapter is to give a short introduction to data ethics related topics and issues in Connected and Automated Vehicles (CAV), being part of the automotive industry, where the connected part also covers the Cooperative Intelligent Transport Systems (C-ITS). The chapter studies scientific literature and reports on vehicle industry and public authorities.

Ethical concerns of data usage have also been raised in transport and mobility. In recent years discussion has revolved around Connected and Automated Vehicles (CAV) ethical questions, also referred as machine ethics. AV implementation and research covers many disciplines such as different fields of engineering, software (including data), law and ethics.

Martinho et al. (2016) gathered official business and technical reports of companies with and AV testing permit in California and gathered findings of ethical issues. The Figure 8 below presents the ethical issues in AV industry. Although the results concern mainly AV related topics, such as safety, common good and human oversight, there are several relevant ethical issues that also relate to data ethics such as cybersecurity, privacy, transparency, design, legislation and certification.

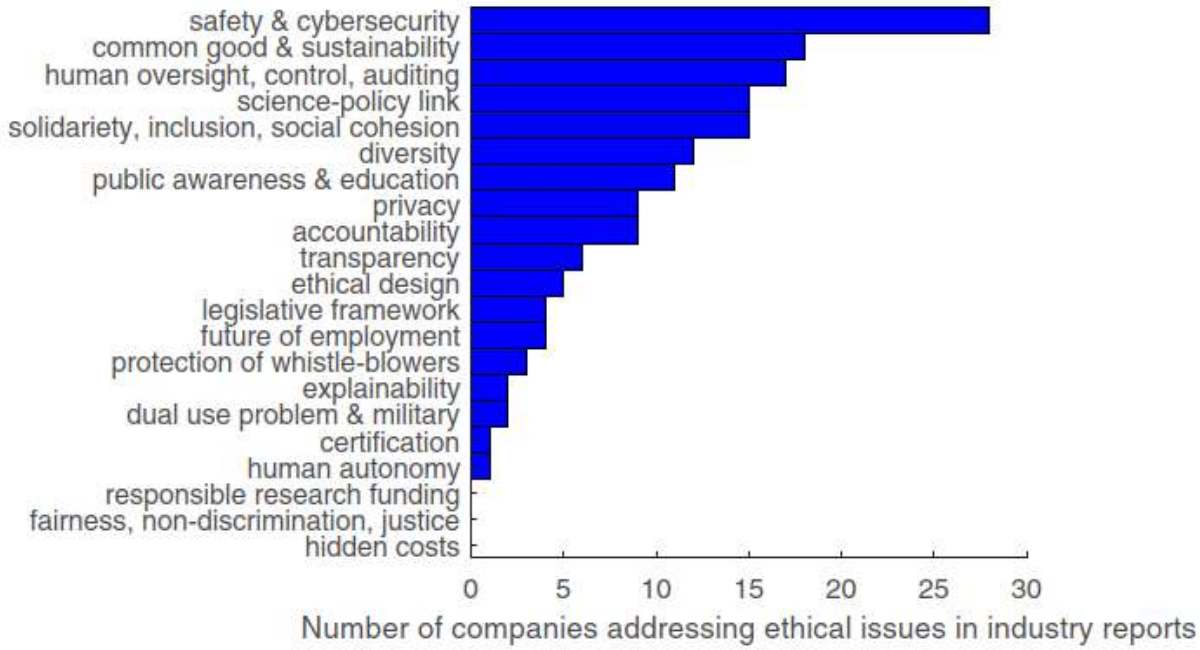

Figure 8 Ethical issues in AV industry according to Martinho et al. (2021).

AV ethical questions are highlighted in the previously mentioned data privacy questions, i.e., how individuals' data is protected and used during the different data processing phases. One other example of data usage in context of AV is given by Bagloee et al. (2016) who refer to cybersecurity and need of redundancy in AV communication capabilities. More than two detection sources should be used for a single observation to help detect any attacks. This requires robust data fusion system and practices that could detect and assist in identifying anomalous inputs. The author of this report suggests that the formerly mentioned example

together with possible manipulation of AV GNSS, database or message data pose a threat that leaves an ethical responsibility for the manufacturer or software developer to practice robust methods and ensure, e.g. by testing, that such threats can be prevented.

European Commission (2020) and Santoni de Sio (2021) have also acknowledged the Ethics of Connected and Automated Vehicles with recommendations on road safety, privacy, fairness, explainability and responsibility. The report includes a chapter on data and algorithm ethics: privacy, fairness and explainability. The following conclusion is given for Connected and Automated Vehicle (CAV) data and algorithm ethics:

> *"The acquisition and processing of static and dynamic data by CAVs should safeguard basic privacy rights, should not create discrimination between users, and should happen via processes that are accessible and understandable to the subjects involved."*

The European Commission (2021) report also noted that to improve CAVs safety it should be publicly demonstrable and monitored through solid and shared scientific methods and data in compliance with basic ethical and legal principles. Therefore, highlighting the need of sharing and quality of data. The Commission report further gives twenty recommendations of which here are mentioned those with relation to data ethics (privacy, fairness, and explainability) in original chronological numbering order. Some of the recommendations have been here further explained (Santoni de Sio 2021):

7. Safeguard informational privacy and informed consent: the Commission identifies the great volumes of static and dynamic data collected and processed by the vehicle which should be safeguarded
8. Enable user choice, seek informed consent options and develop related best practice industry standards.
9. Develop measures to foster protection of individuals at group level, e.g. driver or passenger, and have strategies to resolve conflicts or disputes between data subjects, data controllers and other parties.
10. Develop transparency strategies to inform users and pedestrians about data collection and associated rights.
11. Prevent discriminatory differential service provision.
12. Audit CAV algorithms.
13. Identify and protect CAV relevant high-value datasets as public and open infrastructural resources.
14. Reduce opacity in algorithmic decisions.
15. Promote data, algorithmic, AI literacy and public participation, i.e., inform and equip individuals and public with necessary tools to exercise their rights.

The Ethics Commission on Automated and Connected Driving appointed by the Federal Minister of Transport and Digital Infrastructure in Germany published a report on automated and connected driving (2017). The report and its extract comprise of twenty ethical rules for automated and connected vehicular traffic. As of the rules a few can be highlighted concerning the data ethics. First, the rule number 15. states that "It is the vehicle keepers and vehicle users who decide whether their vehicle data that are generated are to be forwarded and used." Therefore, the rule emphasizes road autonomy and data sovereignty of road users. Secondly, the rule number 18. states that self-learning systems and their connection to scenario databases may be ethically allowed if they generate safety gains. The report further presents utilisation of data between security, personal autonomy and information self-determination that for example seek solutions that meet the requirements of data processing and data utilisation. (Federal Ministry of Transport and Digital Infrastructure 2017)

European Climate, Infrastructure and Environment Executive Agency (CINEA 2023) has

published a report Towards Cooperative, Connected and Automated Mobility (CCAM) about contributions of Horizon Europe projects. Horizon Europe socio-economic and environmental aspects also ethics. AI4CCAM project refers to the European Commission expert group report of Ethic Guidelines for Trustworthy AI. AITHENA project also covers ethics and sensitive data in AI quality measurement and methodology development.

5.3.2 Code of ethics and decision making

Code of Ethics is defined as a set of rules about good and bad behaviour according to the Merriam Webster dictionary (2025). The Institute of Business Ethics defines Code of Ethics as a compass guide how to do business or like a map for guidance when there is a choice to make (IBE 2025). The following paragraphs provide industry examples of Code of Ethics content.

Presence of a code of ethics in organisations have been found having a positive impact on perception of ethical behaviour, even when respondents did not recall specific content of the code of ethics. The study was conducted with companies having code of ethics (n = 465) and companies without codes (n = 301). (Adams et al. 2001)

Set of universal moral standards was proposed by Schwartz (2002). The set included (1). trustworthiness; (2) respect; (3) responsibility; (4) fairness; (5) caring; and (6) citizenship. The set was proposed to be used for corporations' code of ethics auditions for compliance. When tested to four Canadian companies, the study found room of improvement from the companies' code of ethics on content, creation, implementation and administration.

Code of ethics in engineering has been studied by Davis (1991 & 2016) who discusses the complex decisions made in the field and how organisations and technical requirements influence decisions. Davis further argues that codes of ethics are important in engineering and to an individual engineer to understand engineering as a profession. Also, codes support and encourage others in the field to follow the code. Those who do not follow the code should be called to account.

Association for Computing Machinery (ACM) Code of Ethics and Professional Conduct has been developed to inspire and guide the people working in the computing field." The Code includes principles formulated as statements of responsibility, based on the understanding that the public good is always the primary consideration." The code is divided into the following three sections. (ACM 2025)

- "Section 1 outlines fundamental ethical principles that form the basis for the remainder of the Code.
- Section 2 addresses additional, more specific considerations of professional responsibility.
- Section 3 guides individuals who have a leadership role, whether in the workplace or in a volunteer professional capacity"

A case study by Bo et al. (2017) about changes being suggested for the ACM Code of Ethics and Professional Conduct suggests that dynamic nature of technology challenges static codes of ethics. The case study concludes that code needs to provide guideline and reminder for the people working in the field that the complex decisions they make affect themselves, people and society.

IEEE Code of Ethics has been published in the IEEE Policies, Section 7 – Professional Activities (2025). The Code recognises the importance of how technologies affect the quality of life and personal obligation of profession. The code agrees the following three main topics:

I. To uphold the highest standards of integrity, responsible behavior, and ethical conduct in professional activities.
II. To treat all persons fairly and with respect, to not engage in harassment or discrimination, and to avoid injuring others.
III. To strive to ensure this code is upheld by colleagues and co-workers.

Satellite operator Eutelsat has published Code of Ethics that includes common values and guidelines of business conduct and behaviour for employees. Four sections include clients and business partners, staff, corporate social responsibility and financial markets and shareholders. (Eutelsat)

World Health Organization (WHO) Code of Ethics and professional conduct includes integrity, accountability, independence and impartiality, respect and professional commitment. (WHO 2025)

Code of Conduct can be mandatory or voluntary (Australian Government 2024): First, prescribed mandatory codes, a set of rules or minimum standards for an industry, including the relationship between industry participants or their customers; secondly, non-prescribed voluntary codes are a form of industry self-regulation. Codes of Conduct may also include ethical guidance and considerations

Codes of conduct are commonly used to govern employee behaviour and establish a socially responsible organisational culture. Companies that maintained high quality codes of conduct have been found being significantly better represented in the corporate social responsibility (CSR) instrument ranking systems for corporate citizenship, sustainability, ethical behaviour, and public perception. This also reflected to ethical rankings. (Erwin 2011)

Council of Europe (2023) has published code of conduct as a comprehensive ethical framework as a set of behavioural and ethical standards and is relevant to every member of staff. The Code of Conduct has two main parts: Integrity and Respect. The Part 1 Integrity includes independence, trustworthiness and responsibility. The part 2 includes dignity, diversity and discretion.

Organisational management of ethics and ethical decision-making in the industry has been discussed as a part of the organisation's activities and decision-making process as presented in the following examples.

The International Telecommunication Union (ITU) has an Ethics Office which promotes ethical behaviour in all the ITU activities. The independent function responsibilities are leading ethical standards; advising management and stakeholders; awareness raising and trainings; addressing misconduct and protecting against retaliation; working with stakeholders and reporting issues; identifying and addressing conflicts of interest; working with the UN System-wide Ethics Network.

Ethical decision-making processes in complex situations, which for example C-ITS can be seen due to high-connectivity and complex traffic situations, has gained attention and decision-making processes and frameworks have been proposed. For example and figures below, Project Management Institute PMI Ethical Decision-Making Framework (2012) (Figure 9) and Ethical Decision-Making Process by Business Ethics Resource Center (Stacey & Elm 2019) (Figure 10).

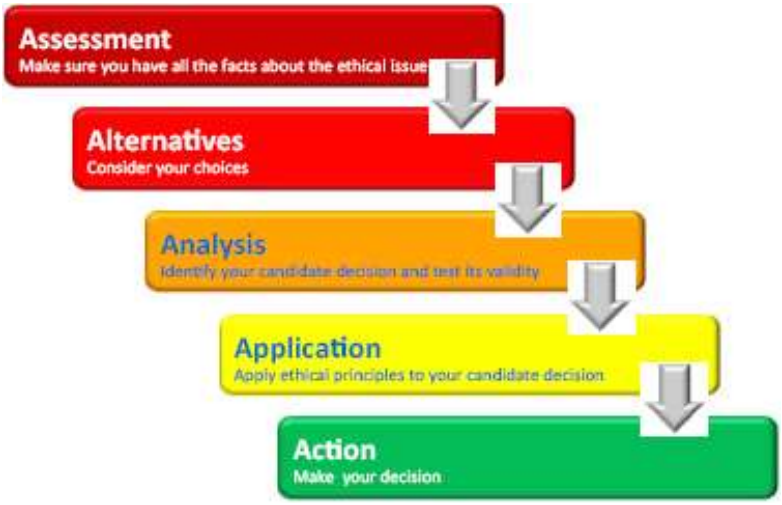

Figure 9 Project Management Institute PMI Ethical Decision-Making Framework. (PMI 2012)

Figure 10 Ethical Decision-Making Process. (Supina & Elm 2019)

5.3.3 Ethical use of data

Tingley (2021) lists five principles of data ethics for business professionals and for organisations (verified ChatGPT summary):

1. Ownership: Individuals own their personal information. Collecting data without consent is unethical and unlawful. Always obtain permission through clear agreements or policies.
2. Transparency: Be open about how data is collected, stored, and used. Clearly communicate your methods and intentions to data subjects, enabling informed decisions.

3. Privacy: Protect individuals' personally identifiable information (PII) by storing data securely and ensuring it remains confidential. Consider de-identifying datasets to maintain anonymity.
4. Intention: Collect data with a clear, ethical purpose. Avoid gathering unnecessary or sensitive information that doesn't directly serve your project's goals.
5. Outcomes: Assess the potential impact of data analysis. Be vigilant about unintended consequences, such as biases or disparate impacts, and strive to prevent harm to individuals or groups.

Open Data Institute (ODI) has published a Data Ethics Canvas (2021) to help identify and manage ethical issues in data projects full life-cycle stages when data is collected, shared or used. The canvas works as an ethical framework to develop ethical guidance for different sizes and scopes of projects. The canvas encourages to ask following questions:

- What is your primary purpose for using data in this project?
- Who could be negatively affected by this project?

The Canvas benefits mentioned are such as improve project planning, grow impact and trust, complement other ethics guidelines, manage data ethics in the long-term. The ODI Data Ethics Canvas (2021) includes the following topics with additional questions, to help a group, organisation or a project to guide through ethical questions and identify as well as manage issues:

1. Data Sources: Identifying and describing data sources, addressing personal or sensitive data involvement.
2. Rights Around Data Sources: Ensuring permissions and compliance for data use.
3. Limitations in Data Sources: Addressing data biases, gaps, and quality issues.
4. Ethical and Legislative Context: Adhering to ethical codes and relevant legislation.
5. Ongoing Implementation: Building processes to address data issues over time.
6. Your Reasons for Using Data: Justifying the project's purpose and societal impact.
7. Positive Effects on People: Identifying and measuring the positive impact of the project.
8. Negative Effects on People: Understanding and communicating potential harm or risks.
9. Minimizing Negative Impact: Steps to reduce harm and improve data practices.
10. Reviews and Iterations: Monitoring and updating responses to ethical challenges.
11. Engaging with People: Ensuring user input, correction mechanisms, and appeal processes.
12. Communicating Your Purpose: Clarity and accessibility of project objectives for stakeholders.
13. Openness and Transparency: Sharing methodologies, data, and outcomes openly.
14. Sharing Data with Others: Evaluating plans for data sharing and publishing.
15. Your Actions: Summarizing steps before moving forward and committing to transparency.

UK government Data Ethics Framework (2020) was introduced earlier in this study. The framework as a “guidance for public sector organisations on how to use data appropriately and responsibly when planning, implementing, and evaluating a new policy or service”. Questions in each of the framework sections guide through ethical considerations and help to assess data ethics. Scoring scale has been decided to help identify project ethical needs.

The framework has three overarching principles and specific actions. First, *overarching principles* are applicable in the entire process. Secondly, *specific actions* guide through

different stages of the project and provide practical considerations. Both are introduced next below.

Overarching principles:

1. Transparency: Actions, processes, and data are open to inspection by publishing information in a complete, understandable, and accessible format.
2. Accountability: Effective governance and oversight mechanisms to ensure that government initiatives meet their stated objectives and respond to the needs of the communities they are designed to benefit.
3. Fairness: Eliminating potential unintended discriminatory effects on individuals and social groups, mitigating biases, and ensuring that projects respect individual dignity, are just, non-discriminatory, and consistent with public interest, including human rights and democratic values.

Specific actions:

1. Define and understand public benefit and user need
2. Involve diverse expertise
3. Comply with the law
4. Review the quality and limitations of the data
5. Evaluate and consider wider policy implications

5.4 Ethics workshops results

Ethics and ethical use of data was part of three TIARA project workshops: one in May and two in November 2024. All three workshops had a main topic and then ethics as a subtopic. Aim was to ensure that ethical questions and issues can be recognised and addressed in each of the main topics and value chain of traffic information. This chapter summaries the workshops results. Workshops material can be found from APPENDIX 1 and APPENDIX 2.

The first workshop in May 2024 of "Authorities and industry views on data usage and responsibilities" the participants were questioned whether they individually or their organisation uses specific ethical guidelines, such as on data ethics. If yes, ethical guidelines are used, what ethics aspects does it cover?

Results showed that the participants did not identify such ethical guidelines, policies or guidance, in their own work or in their organisation. This of course does not imply, that one could not exists, but at least awareness of such ethical guidelines was non-existent.

The second workshop in November 2025 was divided into two 45 minutes sections around two stages of traffic information value chain (Figure 11): content and service. The two topics were as follow:

1. Content: Communication and dissemination of road operator data content to users
2. Service: Development and service provision of ITS and C-ITS services to road users

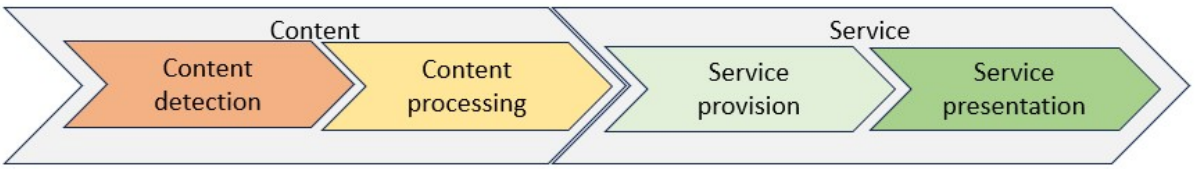

Figure 11 Value Chain of Traffic Information. (EU EIP 2022)

Both of the two topics of content and service included also data ethics. The participants were asked to consider also ethical questions and issues when evaluating and discussing content

communication and service provisioning. An interactive board was used where participants could in addition of discussion to write down notes. The following is a summary of the discussion and participants' feedback.

1. Communication and dissemination of road operator ITS/C-ITS data content to users

The participants were presented the following Table 5 introduction and reference questions on ethical questions during the workshop.

Table 5 TIARA workshop 4 November 2024 ethical questions.

Ethical questions
Ethical considerations or issues when communicating and disseminating data content to users in ITS or other industries?
Is it ethical to provide **inaccurate information** when we are fully aware that it is inaccurate?
What **European regulation and policies** could be related to ethical data communication and dissemination?
Does your organisation have, or have you observed elsewhere **ethical guidelines, code of ethics or other similar guidance** related to data content communication?

The participants presented the following ethical questions or statements during the discussion which are summarise and organised here by topic after analysis:

- Data and quality
  - Would you disseminate data sets that are not concurred?
  - Who is liable of bad data quality which is ethical as well.
  - It is ethical to provide inaccurate data as long as the level of quality is also given?
  - What can be actually measured? What are the costs and is there an ethical consideration in the costs? Hidden bias on the data, e.g. trained data / Machine Learning (data dissemination and ethics)
- Business models: Should Safety Related Traffic Information (SRTI) be provided free of charge and for everyone (data dissemination and ethical question)?
- Privacy
  - Privacy issues on data communication: what questions to ask from the user (data dissemination and ethics)?
- Knowledge and pilots: C-ITS pilots should provide knowledge about ethical and legislation as well as dissemination of results.
- Design and management
  - Ethics by design. Ethics need to be design in the system from the start.
  - Risk management principles applying to ethics.
  - Data ethics framework in UK.
- Users
  - It is ethical to ensure that people understand the implications of data collected about them.
  - Not ethical to provide information only to people with technical skills.
- Dissemination
  - C-ITS pilots should provide knowledge and disseminate about quality, reliability, ethical, legislation. C- ITS pilot example: quality levels defined during the pilot but not disseminate to public or users.

-

2. Development and service provision of ITS and C-ITS services to road users

The participants were presented the following Table 6 introduction and reference questions on ethical questions during the workshop.

Table 6 TIARA workshop 5 November 2024 ethical questions.

Ethical questions
Ethical considerations or issues when developing and provisioning of services to users?
Is it ethical if it is known that **service provisioning has issues** and not have common standards or requirements in place?
What **European regulation and policies** could be related to ethical service development and service provision?
Does your organisation have, or have you observed elsewhere **ethical guidelines, code of ethics or other similar guidance** related to development and provisioning of services?

The participants presented the following ethical questions or statements during the discussion which are summarise and organised here by topic after analysis:

- Business models: Road operator setting up their own services compared to private industry providing the service, i.e. public authority responsibility vs. business models (data provision and ethical question)
- Users: Vulnerable Road Users (VRU) services are not in forefront of the current C-ITS services as most services are vehicle cantered (data provision and ethical question)
- Roles and responsibilities: Is there a role for government in ensuring services are safe? For example, if there is a service that highlights areas with no speed cameras or shows adverts to drivers. Need for European NHTSA?
- Design and management
    - Ethics by design.
    - Follow basic global ethical rules that are part of the engineering and governance.
    - Difference between ethical and accessibility as well as affordability, e.g. ADAS.

Additional ethical questions and issues related to ITS and C-ITS are presented in the below list. These topics were identified based on the workshops and other discussions as a part of the research. The topics have been organised in three categories: data quality, data protection and privacy as well as service and data misuse.

Data quality

- If you know your traffic data quality is questionable and maybe even not useful for the users, should you still open and share the data as required by the ITS Directive?
- Road operators providing (open) data for the use by various service providers or road users should always specify the quality (including accuracy) of their data in a way that correctly describes the actual quality in the various situations and conditions. If the data quality is not known, it is also ethically appropriate to openly make this clear to the possible users of the data so that they do not have any false expectations.

- Data usage beyond accuracy, e.g., how the data is used? Where is the limit for data to be defined as poor quality?
- Certain data quality level should be maintained throughout the life cycle of the data, i.e. data quality does not end when opening the data. It would be unethical to not acknowledge the responsibility to maintain and even enhance the data quality if possible.
- Terms of use for the data announcing the data as “information only “, i.e. transfer of responsibility for the data user, may include ethical issues if especially at the same time there is knowledge regarding issues in the data quality. For comparison, many of the C-ITS use cases and data can be found from the TISA 5-star ratings, where the data provided announces and is evaluated by data quality rating.

Data protection and privacy

- What location data is safe and ethically correct to share? For example, high frequency transmission of road maintenance trucks and maintenance vehicles such as winter maintenance. Compare to emergency service vehicle location data that is highly sensitive for sharing.
- C-ITS Collective perception service, that shares safety related traffic information about the road environment and vehicles, could show something unwanted and unethical.
- Misuse of personal data using data processing methods that reveal private information. These techniques and risks are discussed further in the TIARA project WP4 Privacy report.

Service misuse

- To gain traffic management and control benefits, an organisation or user may use the C-ITS service unethically, even if from a legal perspective the use would be correct. For example, public transport signal priority wrongfully used and benefitted by the user.

5.5 Analysis of data ethics

Ethics, what is right and wrong, concerns individuals and organisations. Ethics should be viewed as a higher-level standard of responsibility and accountability which goes beyond the minimum requirements of law and regulations.

Regarding the ITS and C-ITS services, use cases and data, several ethical questions and issues were identified in the study and workshops. In addition of addressing these questions, there should also be a process and a systematic way to identify and solve these questions and issues.

Although ethical questions and issues were identified, no ethical guidelines, code of ethics nor code of conducts were identified in use by the organisation and in wider context of the European C-ITS ecosystem. This doesn’t mean that they do not exist due to limited research quota. This has not been uncommon in the industry earlier, as according to the Schwartz (2002) study, room of improvement has been found from the corporations’ code of ethics auditions for compliance. According to the study results presented in the chapter, such as Adams et al. (2022), organisations with a code of ethics or code of conduct have been found to have a positive impact on the perception of ethical behaviour. Davis (1991 & 2016) presented that code of ethics are important for the engineering profession, i.e. engineering in general, which ITS and C-ITS are included.

Work has been done on ITS and C-ITS related field of Connected and Automated Vehicles

and organisational management of ethics and ethical decision-making, which all provide recommendations and decision-making frameworks for ethical decision-making. These recommendations could be well adapted, such as Tingley (2021) list of five principles, to the field of ITS and C-ITS.

Dynamically changing technology poses challenges to the code of ethics. Although a review of the codes is needed, it is reminded that it is peoples' responsibility who work with the complex topics to understand the impact of their work to others and society. Therefore, in addition to organisations, individual responsibility and ethical behaviour have an impact on decision-making. Engineering field employees may also belong in one of the fields associations presented in this chapter, such as ACM, IEEE or ITU, which have code of ethics and therefore these could reflect to the C-ITS field.

Ethical questions and issues also depend on the type ITS / C-ITS service and use case. Each use case and situation where it is used are different. For example, static road works warning service and use cases have a limited impact on user data privacy and less risk of ethical issues on implementation. Meanwhile any use case where location data is shared with high frequency, e.g. probe vehicle data (or floating car data) using C-ITS CAM messages, poses risks for unethical use of the data, even if with good intensions. Other ITS and C-ITS services such as In-Vehicle Signage (IVS) and use case of traffic sign or digital traffic rules and regulations can also include higher ethical questions for the data accuracy and responsibility, especially in future when this information is used by automated vehicles and AI systems.

The following conclusion, which includes three recommendations, aims to fill in the above identified gab on ITS and C-ITS engineering field lack of ecosystem, organisation and operational level code of ethics.

The analysis concludes the following three strategic, tactical and operational level recommendations for road operators based on ITS and other industries' lessons on ethical use of data:

1. Strategic level: Implementation of ITS and C-ITS code of ethics to address ethical values when implementing services and use cases as well as when using data. The compliance to and use of a code of ethics as a basis for operations can also be identified from related domains such as automotive, telecommunication or information technology.

2. Tactical level: Assigning a responsible member or part of an organisation to introduce the ITS and C-ITS code of ethics in the organisation and handle any questions or issues that may arise in future. This includes whistleblowing, when an issue arises, and devising decision-making processes for ethical questions. Also, education and training on ethical topics for the employees can be organised as it is the individuals, as a part of team and organisation, who build and implement the services and use of data.

3. Operational level: Use of a specific ethical framework in new and existing ITS and C-ITS projects to identify any ethical issues. For example, the Open Data Institute (ODI) has published a Data Ethics Canvas (2021) to help identify and manage ethical issues in data projects' full life-cycle stages when data is collected, shared or used.

6 Inclusive communication and development of C-ITS services to road users

6.1 Road users as a target audience and service end users

Road users were the target of communication as stated in the research questions. The ITS Directive 2010/40/EU ITS defines ITS users as follow, including also definition of vulnerable road users:

> *"ITS user' means any user of ITS applications or services including travellers, vulnerable road users, road transport infrastructure users and operators, fleet managers and operators of emergency services."*
>
> *"Vulnerable road users' means non-motorised road users, such as pedestrians and cyclists as well as motorcyclists and persons with disabilities or reduced mobility and orientation."*

The ITS Directive delegated acts mentioned in the previous chapters also include users of safety related traffic information, data users and end-users (EU 886/2013; EU 2022/670). In this study the following definition is applied from the ITS Directive 2010/40/EU:

> *"Road user means motorists such as people driving vehicles, vulnerable road users such as pedestrians and cyclists, road transport infrastructure users and operators, fleet managers and operators of emergency services."*

Therefore, road users utilise the C-ITS services and have access to the service messages on the road. The literature material reviewed included studies and frameworks where the data user was also for example an organisation or developer who uses the data often to provide services – these are out of scope in this study which only limits to users who physically use the road infrastructure as referred in the directive definition above.

Road infrastructure is used by many different road users and stakeholders who all have somewhat similar needs, e.g. road safety, but also different needs such as freight company and driver might require accurate data on delivery zones. The following road user groups were adapted and identified from the ITS Directive and CEDR DROIDS project Soni et al. (2025) report:

- Vehicle owner/ driver/ occupant
- Vulnerable Road Users (VRU), e.g. pedestrians and cyclists
- Motorcyclist
- Law enforcement
- Rescue service provider
- Commercial, delivery, logistic and freight operators
- Public transport operators
- Road infrastructure authority or contractor operating on the road
- Road works or maintenance contractor
- Vehicle fleet operator
- Vehicle manufacturer and service provider
- Automated Driving Systems (ADS) provider

Specialised groups of road users, such as people who are mobility impaired or disabled with specific needs. These disabilities can for example be and presented by the UK Government Digital Services (2024) with additional examples added:

- impaired vision
- impaired hearing
- motor difficulties
- cognitive impairments
- learning disabilities
- deafness or impaired hearing
- low literacy

It should be noted that medical requirements with physical qualifications for vehicle drivers are required in European Member States. Regular monitoring takes place as drivers need to pass examination to qualify for a driving license. These requirements itself limit the specialised group of road users and provide a baseline a fit driver, e.g. driver with qualified cognitive skills to drive a motor vehicle.

Technical ability and capability of road users should also be considered. Different users, for example part of the above presented groups, have different understanding about the availability and usage of C-ITS systems and services, e.g. meaning and impact of the services and usage of the services User Interfaces (UI). For example, novice drivers, experienced drivers and elderly drivers might have different understanding of the services technical capabilities and usage.

6.2 Design concepts and terms in literature

This chapter reviews commonly used design principles and concepts as well as terms used to describe these approaches. The chapter scope limits especially to approaches that aim to build services and products, such as ITS and ITS represent (software and information technology), that are easier for people to use. Large groups in society could be supported by Information and Communication Technology (ICT), such as C-ITS services, but the technology need to be designed to fit peoples' cognitive abilities so that they are able to use it (Cremers et al 2013).

Accessible design refers to design process where needs of people with disabilities are specifically considered. **Accessibility** is often referred to the "characteristic that products, services, and facilities can be independently used by people with a variety of disabilities".

Accessibility standards exist for example on software, hardware and other information technology (DO-IT University of Washington). Accessibility design testing can also include testing of the products and services for different user groups. 'Universal Accessibility' guidelines have been developed for people with a variety of limitations (Cremers et al 2013).

Inclusive design relates to traditional terms of "design for all" and "universal design" (see next paragraph) (Cremers et al 2013). Universal design considers human diversity with respect to ability, language, culture, gender, age and other forms of human difference, i.e. people with special needs. Three dimensions proposed by Inclusive design research centre are as follow and presented in Figure 12. (Inclusive design Research Center)

1. Recognize diversity and uniqueness
2. Inclusive process
3. Tools and broader beneficial impact

Figure 12 The Three Dimensions of Inclusive Design (Inclusive Design Research Center)

Universal design is referred similarly as inclusive design as "products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." As the name describes, aim is to everyone to benefit, e.g. make the letters larger, high-contrast and making things adjustable to enable more people to use them. Flexible design that offers a chance and allow people to adjust for example lightning and font size. (NC State University; Norman 2013)

Human-Centered Design (HCD) is defined by Norman (2013) as a process that ensures that the design matches the needs and capabilities of the people for whom they have intended. In other words, ensuring that the correct problem is solved. The iterative cycle of HCD includes:

1. Observation
2. Idea generation (ideation)
3. Prototyping and
4. Testing.

Norman further describes the process as follows:

> *"A usable design starts with careful observations of how the tasks being supported are actually performed, followed by a design process that results in a good fit to the actual ways the tasks get performed. The technical name for this method is task analysis." (Norman 2013)*

User-centered design (UCD) is a methodology that prioritizes the needs, preferences, and limitations of end users throughout the design and development process of digital systems. UCD aims to enhance functionality of digital systems and enhance accessibility and usability so that the systems are "intuitive and accessible to a diverse range of users, including those with disabilities, varying levels of digital literacy, and different cultural backgrounds". UCD

techniques include persona development, task analysis, usability testing, and participatory design. UCD focus is on the following (Emma 2024):

- Iterative testing
- User feedback, i.e. involving end-users in all stages of development
- Continuous refinement to create systems that offer seamless, effective, and enjoyable user experiences.

Usability refers to making systems easy to use for all users so that the users can reach their task goal. Usability has been defined in the ISO 9241-11 (2018) standard as "Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of us." (NIST). The ISO standard provides a framework for understanding the concept of usability and applying it to situations where people use interactive systems and services (including technical and personal services). Usability has been defined by Nielsen (1994) as follows:

- Learnability: the system should be easy to learn so that user can rapidly start getting work done.
- Efficiency: the system should be efficient to use to gain high level of productivity.
- Memorability: the system should be easy to remember, so that casual user is able to return.
- Errors: the system should have a low error rate an easy recover with no catastrophic errors.
- Satisfaction: the system should be pleasant to use so that users are subjectively satisfied when using it.

User experience (UX) refers to how user experiences and interacts with the service. Design teams use UX design to create meaningful experiences. It may also include experiences related to the services, for example marketing (Interaction Design). **Human Factors** refers to a field of study of human abilities, limitations behaviours and processes to inform human-centred designs (Michigan Tech). **Human-Computer Interaction (HCI)** is a field of study on design of computer technology and how the technology interacts with humans, i.e. the user, which interaction is followed by the HCI researcher.

6.3 Accessibility and inclusive design legislation, standards, guidelines and principles

This chapter presents inclusive design guidelines and principles found from the literature. Review of general inclusive design principles is followed by design principles that are specific for transport and mobility.

European accessibility act (EU 2019/882) is a "directive that aims to improve the functioning of the internal market for accessible products and services, by removing barriers created by divergent rules in Member States". The act covers wide range of products and services from computers and operating systems to smartphones and audio-visual media services. Persons with disabilities and elderly people will benefit from the act. Conformity assessment procedures are required from products and services. (European Commission 2021)

The accessibility act is transposed to national law. In addition, there can be other national laws in the European Member States. An example of the legal duties is the UK Equality Act 2010 for government communicator. (UK Government Digital Service and Central Digital and Data Office 2024)

European Union Strategy for the rights of persons with disabilities 2021-2030 aims to deliver further significant improvements to all areas of the lives of persons with disabilities within the EU and beyond. The Strategy builds on the results of the previous European Disability Strategy 2010-2020. (European Union 2021)

Accessible guidelines have been developed for people with variety of limitations. The guidelines are a source of information for inclusive user interface design and evaluation. Following are examples of design principles for different user groups by Cremers et al. (2013):

- Elderly people (Fisk et al., 2009)
- Children (Hourcade, 2008)
- Design 'considerations' for persons with a cognitive disability (WebAIM, Van der Pijl et al., 2005)
- People of low literacy (Cremers et al., 2012).

The following inclusive and accessibility guidelines as well as standards are published by European and international organisations, i.e. official bodies. The guidelines are here shortly introduced with the official source:

- *International Organization for Standardization (ISO)* has published accessibility standards for development of accessible products and environments. These include for example ISO/TR 22411, Ergonomics data for use in the application of ISO/IEC Guide 71:2014, that helps standards developers to understand human characteristics and capabilities of persons with disabilities and older persons. Also Guide 71 addresses accessibility in standards. (ISO Accessibility for all)
- *European Telecommunications Standards Institute (ETSI)* has a technical committee on Human Factors (HF) and accessibility which produces ETSI standards, guides and reports to promote (electronic) e-accessibility by adopting "Design by all" approach. The standards include for example Guidelines for ICT products and services, User-centred terminology for existing and upcoming ICT devices, services and applications. (ETSI HF)
- *The World Wide Web Consortium (W3C)* publishes accessibility standards and guidelines which are provided in the W3C homepage. These include for example web content, user agent and technical specifications. W3C aims to support for example visual disorders. (W3C Accessibility Standards Overview)

A large collection of inclusive design toolboxes are available as mentioned and introduced by Cremers et al. (2013) whom These toolboxes are directed to different phases of the design process such as specification and evaluation. Cremers et al. (2013) mention the following design toolkits:

- *Inclusive design toolkit*: description of all possible target groups and their capabilities and design guidance for each capability.
- *55plus toolbox*: focus on product development and marketing and sales.
- *UCD toolbox*: overview of 35 design methods with pre-selected criteria: type
- of product, design goal, resources, participants and method characteristics.
- *HCD toolkit*: human-centered design process that supports in activities such as building observation and empathy skills, prototyping, leading workshops, and implementing ideas.

Accessibility requirements for public sector bodies have been published by the UK Government Digital Service and Central Digital and Data Office (2024). The guidance has been mainly directed to website and mobile app accessibility. The requirements guidance tools

include

- Meeting the Public Sector Bodies Accessibility Regulations
- Making your projects, programmes and infrastructure accessible and inclusive
- Designing accessible services
- Designing accessible content
- Creating accessible communications
- Testing with accessibility personas
- Accessibility training
- Your website accessibility statement
- Join the accessibility community

European projects for inclusive, accessible, affordable, and fair transport system for all European citizens were launched as a part of the EU-funded Horizon 2020. The results pack highlighted 11 projects which of the DIGNITY project relating to inclusive design are presented next. (CORDIS research results 2023)

Inclusive design toolkit in transport service design was developed as part of the DIGNITY DIGNITY (DIGital traNsport In and for socieTY) project which was funded by the European Union Horizon 2020 research and innovation programme. The aim of the project was to foster a sustainable, integrated and user-friendly digital travel eco-system that improves accessibility and social inclusion. The project developed the DIGNITY toolkit help policymakers, public and private mobility entities and transport providers to develop more inclusive digital mobility solutions (Figure 13). (University of Cambridge; DIGNITY Toolkit)

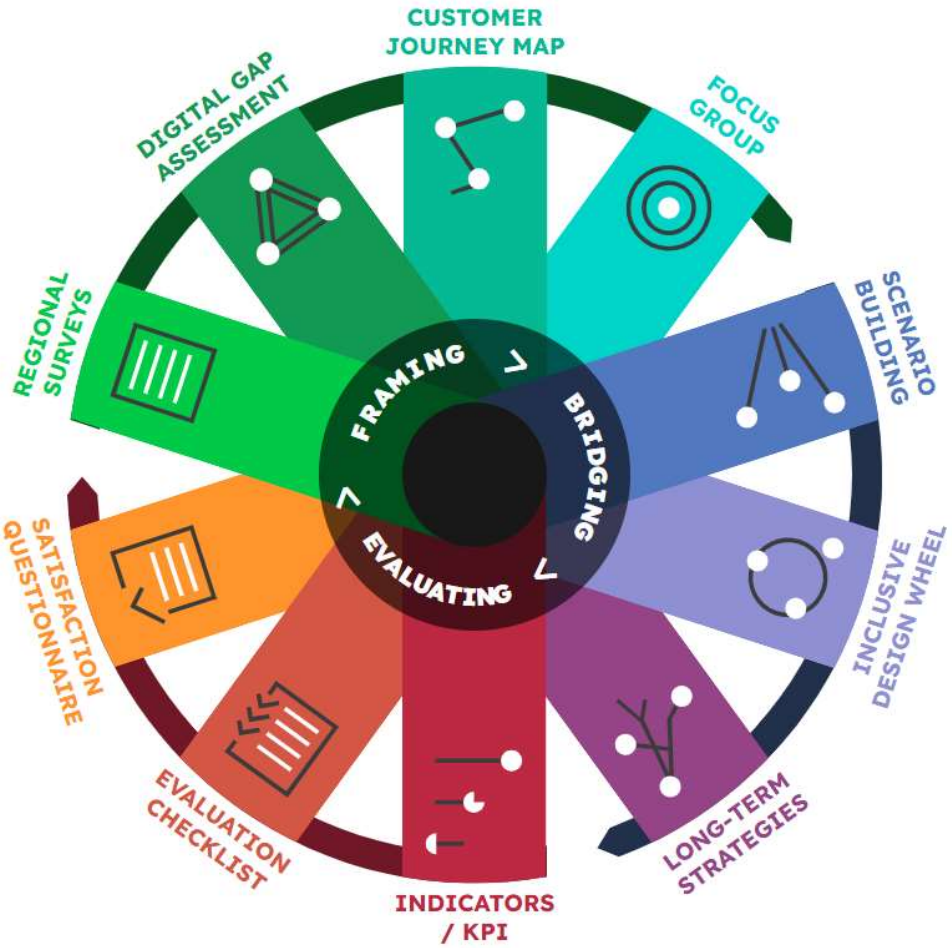

Figure 13 DIGNITY Toolkit designed to help (regional) governmental institutions and mobility providers bridge the digital gap and help create more inclusive policites, products and services. (DIGNITY Toolkit)

Inclusive Design Wheel was presented as part of the DIGNITY toolkit and shown in the below Figure 14. The Inclusive Design Wheel was developed for transport forms as an iterative process framework for designing inclusive products and services. The main phases of the framework are as follow. (University of Cambridge; DIGNITY project; DIGNITY Toolkit)

1. Manage: Review the evidence to decide ‘What should we do next?’
2. Explore: Determine ‘What are the needs?’
3. Create: Generate ideas to address ‘How can the needs be met?’
4. Evaluate: Judge and test the design concepts to determine ‘How well are the needs met?’

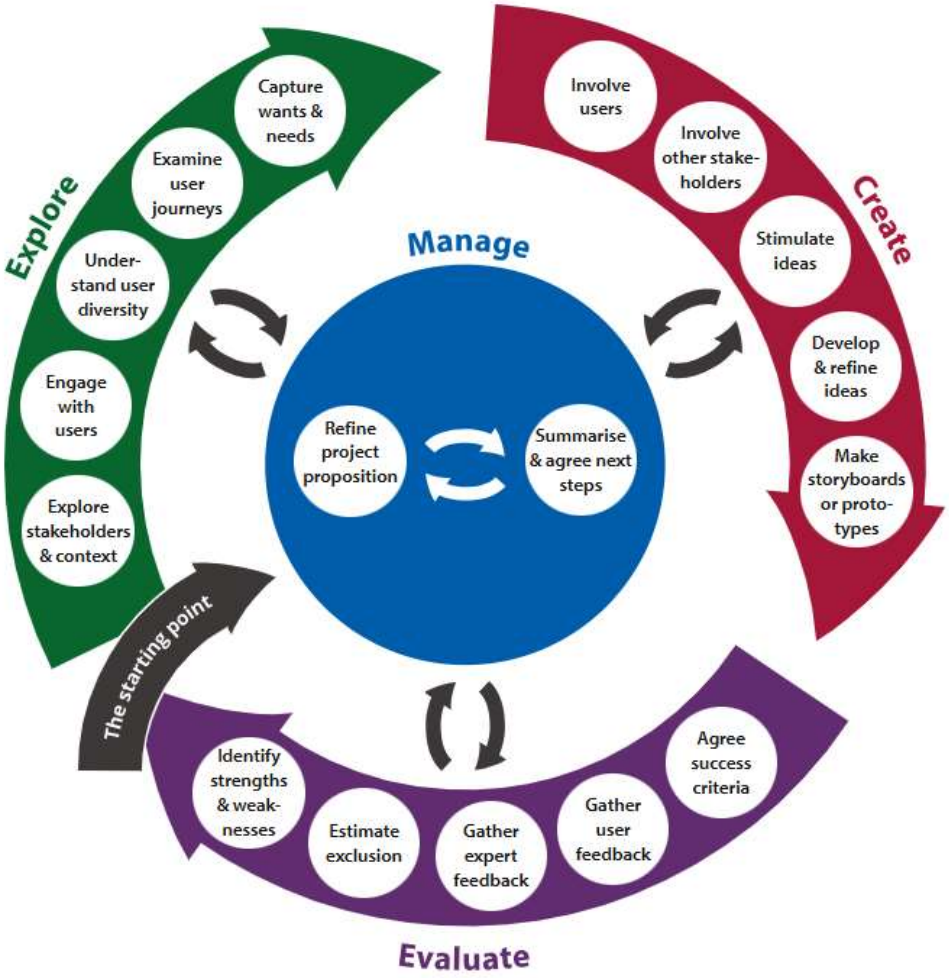

Figure 14 Inclusive Design Wheel – Map of key activities for transport. (DIGNITY; University of Cambridge)

The DIGNITY project presented the following eight final policy recommendations to address the risks of exclusion associated with the development of digital mobility solutions. (DIGNITY Final Recommendations)

1. Recognise that the digital gap in mobility is a complex and multifactorial issue that requires sound research inputs
2. Ensure a coordinated governance system across multiple sectors and stakeholders
3. Ensure that digital products and services are codesigned to be inclusive and usable by as many people as possible
4. Ensure that accessibility is prioritised above market dynamics
5. Advocate for the use of intersectional approaches when analysing characteristics, needs and requirements of vulnerable-to-exclusion groups
6. Promote policies aimed at improving gender inclusion in mobility systems
7. Raise awareness of and build capacity on the issue of digital exclusion in mobility
8. Enhance dissemination strategies and diversify communication channels to effectively reach people who are at risk of digital exclusion

6.4 Communication and dissemination of data content to users

6.4.1 Scope of the study and research question analysis

This chapter studies communication and dissemination of data content to road users. Therefore, the chapter discusses the first Content part of the traffic information value chain as presented in the below Figure 15 by EU EIP (2022).

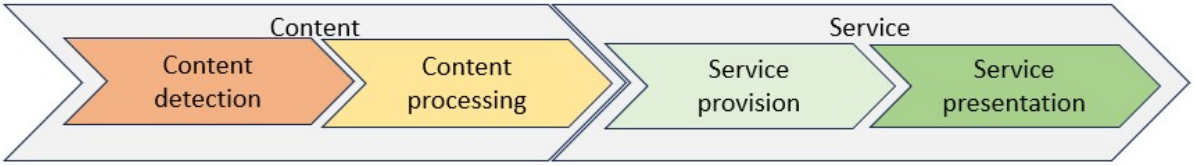

Figure 15 Value Chain of Traffic Information. (EU EIP 2022 & TISA Position on Quality of Traffic Information 2016)

Analysis of the research questions was conducted to clarify the research problem. The communication and dissemination of data content to road users' literature review and workshop results was based on the following original three research questions introduced in Chapter 1:

- Guidance on best practice for the communication of data and its limitations with road users.
- Views on how to be open and transparent with roads users on the use of data.
- Review of how communications around the use of C-ITS systems and data can be ensured to be inclusive of road users across technical ability.

The three above research questions were seen related to each other as follow: First, all the research questions consider the first phase of traffic information value chain, i.e. data content, and communication and dissemination of the data content. Secondly, communication about data quality and data limitations in an open, transparent and inclusive manner, have similar aim of outcome, i.e. for road users with different technical abilities to understand use of C-ITS systems its data. It should be noted that both the C-ITS systems and data used by the systems are included. Also, as mentioned in the scope of the study earlier, both ITS and C-ITS systems and services are included due to similarities of services, outcome for users and use of data. Therefore, the research questions were merged and reformulate to one research question as follows to consider the above-mentioned factors:

> *What are best practices for open, transparent and inclusive communication of ITS/C-ITS systems, their data quality and limitations as well as purpose of use for road users with different technical abilities?*

6.4.2 Data quality communication to users in literature

TISA 5 Star Quality Rating has been proposed by Service providers TomTom, HERE Technologies, Be-Mobile, Google Maps. Aim is to give road operators a helpful, practical and easy-to-use tool to self-assess the quality level of their traffic data. This can be then easily communicated forward. (TISA 2024)

DataONE Best Practices Working Group (2011) presents communication of data quality from information quality control and quality assurance perspective with included metadata guidance. The following general best practices can be identified:

- Qualify (flag) data
- Describe the quality control methods
- Describe standards or test data used for the quality analysis.
- If data with qualifier flags are summarized to create a derived data set, include the percent flagged data and percent missing data in the metadata of the derived data file

CEDR PRESORT project studied use of third-party data. The objective of PRESORT was to provide guide on how National Road Authorities (NRAs) can make better decisions regarding how and when to acquire and use third-party transport data. The project's expected outcomes included a comprehensive understanding of the challenges and opportunities related to third-party data usage in NRAs, identification of specific use cases where third-party data can provide the most significant benefits, development of an actionable guide and data catalogue as well as dissemination of knowledge and best practices related to third-party data utilization. The project also studied procurement of the third-party data which raises the importance of communication between the suppliers to alleviate risk of quality issues. (Laine et al. 2025)

Data quality communication has been presented in the Government Data Quality Framework published by the UK Government Data Quality Hub (2021). The initiative describes the need to communicate data quality to users with following reasons and examples:

- Different users which all have different purposes to use the data.
- Demonstration of strengths and limitations of your data so that users may decide if useful for them.
- Providing fuller picture of data and its journey.
- Mitigate against people using the data for wrong purposes and therefore risk of costs,
- Minimise risk of financial or reputational damage
- Give users confidence in the data and use of it.
- Promote and maintain confidence and integrity of your organisation.
- Poor quality of data needs to be communicated to prevent misuse and bigger risks. Might be usable to some but unknown if not communicated.

<u>Five principles of data quality</u> are included in the Government Data Quality Framework (2021) that provide guidelines for teams and organisations with best practices. The five principles are presented below with parts that include communication about data.

1. Commit to data quality
    - 1.1 Embed effective data management and governance: Data practitioners should ensure that measuring, communicating and improving data quality is at the forefront of activities relating to data
    - 1.2 Build data quality capability: dedicate time and resource to building capability in assessing, improving and communicating data quality through training and sharing best practice
2. Know your users and their needs
    - 2.1 Research your users and understand their quality needs: regularly communicate with users to understand any changes in their requirements
3. Assess quality throughout the data lifecycle
    - 3.2 Communicate with users and stakeholders across the lifecycle
        - develop effective communication channels with and between stakeholders to ensure a broad understanding of data quality
        - communicate any changes in data quality to stakeholders at all stages of the lifecycle
        - proactively engage with data providers to ensure a clear understanding of data quality requirements
4. Communicate data quality clearly and effectively

- 4.1 Communicate data quality to users
    - provide clear data quality information and describe its impact on use of the data
    - communicate trade-offs in data quality clearly to aid understanding of the data's strengths and weaknesses
    - be transparent about the quality assurance approach taken and communicate data quality issues clearly to users
    - build strong relationships with suppliers of external data to identify data quality problems at source
    - inform users in advance about changes made to data processes which could impact on quality
    - communicate clearly and in plain language, following relevant style guides for published materials
    - provide clear definitions of terminology used and not presume a high level of user understanding of data quality
- 4.2 Provide effective documentation and metadata
    - document and share metadata to minimise ambiguity and enhance opportunity for data access and reuse
    - document and report data quality issues and be transparent about steps being taken to address them

5. Anticipate changes affecting data quality

- Not all future problems can be predicted. Where possible, anticipate and prevent future data quality issues through good communication, effective management of change and addressing quality issues at source.
- 5.1 Plan for the future:
    - regularly communicate with users to keep up with changing data and quality requirements
    - ensure metadata and other supporting documentation is thorough and up-to-date

Data lifecycle, i.e. way of describing the different stages that data will go through from collection to dissemination and archival/destruction, is described with also following considerations on communication about the data (Government Data Quality Framework 2021):

- *Quality across the data lifecycle*: Throughout the data lifecycle, those involved should be aware of future users of the data and possible onward uses of the data, and should ensure that data quality at each stage is documented and communicated clearly.
- *Collect or acquire, and ingest*: capture appropriate metadata
- *Prepare, store and maintain*: risk of lack of informative metadata

Six data quality dimensions, i.e. measurable features or characteristics of data, by DAMA UK have been described in the framework. The dimensions are Completeness, Uniqueness, Consistency, Timeliness, Validity and Accuracy. In addition, importance of user needs is highlighted with possibility of trade-offs between dimensions of data quality. The following is a summary of the part dimensions where communication of data is mentioned (Government Data Quality Framework 2021):

- *Accuracy*: Bias in data may impact accuracy. When data is biased, it means that it is not representative of the entire population. Account for bias in your measurements if possible, and make sure that data bias is communicated to your users.
- *User needs and trade-offs*: it is important to communicate these trade-offs to the users of your data to avoid ambiguity and misuse of the data.

Communicating data quality to users chapter in the guidance includes the following on what

users need to know about the data (Government Data Quality Hub (2021) Guidance):

- Is the quality as expected from the terms of agreements in place?
- Are there any changes to data that users need to know about?
- Are there any caveats to the data?
- Does the data quality meet the data quality dimensions (note: dimensions as mentioned above)? Includes background to the data, e.g. parties involved, stages of lifecycle and who collected the data.

The framework case studies have following examples and best practices when communicating data (Government Data Quality Hub (2021) Case studies):

- Make data quality matter on a personal level – articulate the why. Communicating the 'why' is critical to the success of any data quality improvement programme. An organisation should consider the best way to deliver these messages – considering a range of non-standard communication tools.
- A data quality information sheet which will act as a briefing sheet for staff will be produced and disseminated via the force intranet. This briefing sheet will be tailored to specific business functions.
- An information 'hub' is available for all updates on the service as it develops, including a clear and visible roadmap for delivery across services.

6.4.3 Open, transparent and inclusive communication

Inclusive design principles presented in the beginning of chapter 6 are in general usable for communication purposes as well. These include noticing openly and inclusively all user groups and informing them throughout the design and development process of the data acquisition and usage.

The DIGNITY project (2022), as presented in chapter 6.3, results include the following recommendation (number eight):

> *"Enhance dissemination strategies and diversify communication channels to effectively reach people who are at risk of digital exclusion."*

The previous DIGNITY project recommendation included the following sub-recommendations to address risks of exclusion associated with the development of digital mobility solutions:

- Provide clear, accurate and consistent information, allowing people at risk of exclusion to make informed decisions on their mobility.
- Use specific and appropriate language and channels for each group targeted (e.g., through involving user organisations).
- Consider non-digital communication options (e.g., mail, in-person services, telephone and peer-to-peer communication) to better reach specific groups (e.g., elderly, migrants).

UK Government Digital Service and Central Digital and Data Office (2024) accessibility requirements for public sector bodies include Inclusive and accessible communications guidance that refers to the UK Government Equality Act 2010. The guidance includes the following:

- Inclusive communications template
- Accessible by default resources
- British Sign Language guidance
- Standard wording for communications briefs
- Further learning and resources

- Possibility to join accessibility community

Same source as previous also includes Inclusive communication documentation to produce communications that include, accurately portray, and are accessible to disabled people. Aim is to communicate using inclusive language, include disabled people, make sure communication is accessible and choose and use appropriate communication channels. Documentation includes the following:

- Inclusive language: words to use and avoid when writing about disability
- Portraying disability
- Using a range of communication channels to reach disabled people
- Accessible communication formats

ETSI ES 202 076 standard of Human Factors Generic spoken command vocabulary for ICT devices and services presents desirable to standardize voice commands for the most common and generic functions and works as an example of standardised vocabulary.

Ethical considerations are part of the open and transparent communication of the services. Similar ethical principles as presented in the chapter 5 Ethical use of data can be applied widely to the communication and results of the analysis, i.e. ethics need to be part of every level of communication from planning to implementation and follow-up.

6.4.4 Workshops result on data content communication

The two workshops in 4th and 5th of November 2025 were both divided into two 45 minutes sections around two stages of traffic information value chain (Figure 11): content and service. This chapter reviews the first content part of the workshop titled as “Communication and dissemination of road operator data content to users”. Workshops material can be found from APPENDIX 2.

- User
  - User can be a machine or for example automated system
  - Do we consider a user as the car driver or the whole group of people in the car?
  - Can users find information when buying the vehicle?
  - Difference between public operator (like police) and private operators?
- Data quality
  - NAP includes metadata but not perhaps on quality
  - GPS data and similar inaccuracies in data quality, common knowledge when learned in practice
  - How can you communicate data quality, so users understand the implications?
  - How can we understand what is inaccurate data, e.g. slippery road? When does it come inaccurate, how bad the quality will need to be? What can be measured?
- Data content
  - Data content separates from the service provision
  - Data attributes communicated enhancing quality of service, for example if a vehicle is registered as adapted vehicle for e.g. disabled person, special ambulance can be sent.
  - In C- ITS only those who have the C- ITS-station receive the messages.
  - Communicate issues in the data, e.g. data field or metadata. What about road user as an end user (who does not read online or data attributes)?

        - TISA recommendation of 5-start data quality evaluation
        - Should be appointed that the specific issue concerns the data in question (difference between data)
    - Data created by users to road operators.
    - Use cases in future when automated driving evolves.
    - Not only communication about the data but relation to other data and system level understanding.
- Data sharing and business models
    - SRTI: should be provided free of charge and for everyone
- Communicating content
    - Language of communication
    - A common and consistent vocabulary for communication across Europe.
    - Vision zero of traffic safety in Europe
    - C-ITS pilots should provide knowledge and disseminate about quality, reliability, ethical, legislation. C- ITS pilot example: quality levels defined during the pilot but not disseminate to public or users.
- Communication channels
    - Social media communication accuracy and reliability can be questioned.
- Legal, rights and principles
    - Fundamental rights of European Union chapter of "right to live"
    - Open data principle for the authorities, includes content and service provision
- Communication time
    - RTTI regulation refers to real- time communication, i.e. as soon as happening should be informed. Incidents can be old if not automatically deleted when their time limit not yet passed.
    - RTTI delegated states that data quality issues should be acknowledge in relevant time.
- Process
    - Analysis of why something went wrong and prevent same problem occurring again.
- Privacy
    - End user consent: what is required, what is being shared? Is it personal data?
    - Privacy issues when asking questions from the user (dissemination and ethics)?
- Costs
    - Costs and metrics of the communication and data (dissemination and ethics)

6.4.5 Analysis of the communication and dissemination recommendations

This chapter presented analysis and recommendations that were collected for road operators on open, transparent and inclusive communication of ITS/C-ITS systems, their data quality and limitations as well as purpose of use for road users with different technical abilities.

The communication recommendations were extracted and analysed from the literature and the study's workshops results presented in this chapter. The main sources included UK Government Data Quality Hub (2021). Some of the recommendations can be repetitive due to importance on several topics and similar feedback found from literature and workshops.

Analysis of the results, presented in APPENDIX 3, was done by evaluating the input and organising the recommendations according to identified topics. ChatGPT GPT4-4 Turbo model

was at final stage used to give its suggestions of the identified main topics which were then analysed and compared to the original results and verified by the researcher.

The analysis results concluded the following recommendations which are below presented in order of communication flow from policy to action. The full analysis results can be found from APPENDIX 3 of this study:

- Follow legislation, rights and principles
- Explain importance of data quality communication
- Develop effective, bidirectional communication with users and stakeholders
- Make communication user-centric
- Make communication accessible and inclusive
- Practice transparent and reliable data quality and service communication
- Ensure privacy and data protection in communication
- Communicate in a timely and responsive manner
- Engage with data providers and users
- Provide education to users
- Provide communication guidelines for all communication
- Create a process for continuous communication monitoring and development
- Practice proactive risk management in communication

6.5 C-ITS service development to road users

6.5.1 Scope of the study and research question analysis

This chapter studies ITS/C-ITS service development and service provision. Therefore, the chapter discusses the second Service part of the traffic information value chain as presented in the below Figure 15 by EU EIP (2022).

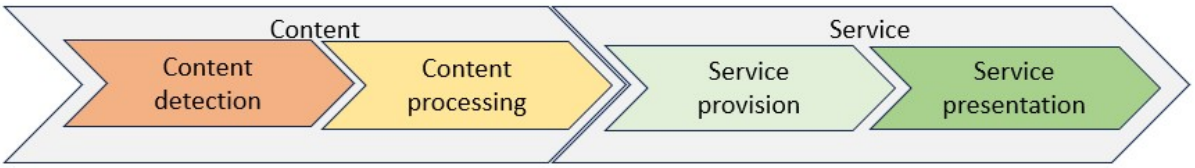

Figure 16 Value Chain of Traffic Information. (EU EIP 2022 & TISA Position on Quality of Traffic Information 2016).

The research objective for the study was as follow:

> *"Guidance on developing C-ITS services that are inclusive of road users across technical abilities."*

ITS and C-ITS service development can have multiple phases from service definition; compliance of standards, regulation and specifications; design of the service architecture; development; user testing and validation; deployment and operations; maintenance. Many of the forementioned phases are also often iterative and therefore repeat several times during the development of the service. ITS project life cycle can also include stages such as upgrading or decommissioning of the ITS project (Zhankaziev 2018).

The scope of this chapter mainly limits to the service presentation, i.e. the final part of the value chain of traffic information where the service with its messages is presented and displayed to the road user.

The Content part of the value chain was discussed in the previous chapter from data communication and dissemination perspective. Here also the service provision part, where the content is processed and enriched for transmission to the user as well as transmitted (radio communications), is seen as a part of the communication and dissemination part of value chain, i.e. how users are been communicated about the service and its data quality.

When service provision is considered, it still should be noted that for example vehicle-to-application communication interfaces can have an impact on inclusive service development for road user. For example, if the road user has an access for his/her mobile device for the service during driving, the familiarity of the user interface and device can have an impact on the inclusivity of the service usage. ITU-T (2013) has for example published report on Vehicle-to-Applications Communications Interface.

It is also assumed here as a prerequisite that for example service architecture has been developed in a way, for example following the ETSI ITS and C-ITS architecture or European C-Roads Platform specifications, that the service developed works for the user, i.e. it is usable and available for different user groups.

The service presentation in the value chain refers to the device where the user receives the service and messages are extracted and rendered to the user, for example on map display on a vehicle user interface or mobile device. This is also seen as the crucial part where users with different capabilities and abilities interpret the received information.

Therefore, this chapter reviews the service presentation development standards, guidelines and recommendations to study the research objective of developing C-ITS services that are inclusive of road users across technical abilities.

6.5.2 Service development industry standards, guidelines and recommendations

This chapter reviews industry standards and recommendations that relate to C-ITS service development from the perspective of legislation, inclusive design and standards. The general terms and design concepts and terms were introduced in the previous Chapter 6.1.

Legislation and regulation from Europe and globally related to service ITS/C-ITS development including Human-Machine Interfaces (HMI) in automotive field include the following.

ITS Directive (2010/40/EU) does not directly enforce development and design of ITS nor C-ITS services but the directive does define the term 'ITS service' as follows :"'ITS service' means the provision of an ITS application through a well-defined organisational and operational framework with the aim of contributing to user safety, efficiency, comfort and/or to facilitate or support transport and travel operations". The definition refers to well developed ITS service for the road users.

The European Commission made a recommendation (2008) on safe and efficient in-vehicle information and communication systems that included an update of the European Statement of Principles on human machine interface.

United States has a federal regulation (e-CFR) title 49 in Transportation Subtitle B in other regulation relating to transportation on Human-Machine Interface (HMI) Design. The regulation states the following in the Appendix E to Part 236:

> *"The product design should sufficiently incorporate human factors engineering that is appropriate to the complexity of the product; the gender, educational, mental, and physical capabilities of the intended operators and maintainers; the degree of required human interaction with the component; and the environment in which the product will be used."*

Barriers and opportunities for developing, implementing and operating inclusive digital mobility services have been studied by Delaere et al. (2024). The study analysis noted a complex challenge where "a lack of effective communication, collaboration, and co-creation across the majority of services, in combination with a widespread failure to disseminate insights among stakeholders, resulting in a lack of knowledge about vulnerable-to-exclusion groups". The study gives the following recommendations for stakeholders:

- *Governments should develop inclusive regulations*: Advocate for and contribute to the development of clear, comprehensive regulations that address the needs of vulnerable populations at both national and European levels. Ideally, involve organisations representing vulnerable groups to provide key insights into the barriers users experience.
- *Enhance co-creation efforts*: Invest in partnerships with social organizations, furthermore developers and operators should seek guidance on effectively engaging vulnerable groups throughout the development and implementation phases.
- *Improve User education*: Next to involving users in the development process, provide targeted education events on digital security and the opportunities of digital transport services to enhance their understanding and safe use of digital tools. Additionally, it would prove beneficial for vulnerable users to communicate with the people behind the application.
- *Simplify GDPR compliance messaging*: Offer simplified summaries of complex regulations, such as GDPR, to help users better understand and comply with data protection requirements.
- *Structure government support*: Push for more structured and goal-oriented government investments in digital inclusion to ensure effective and impactful use of resources.

Inclusive Digital Mobility Solutions (INDIMO), a Horizon 2020 project to digital inclusion in mobility and logistics was based on universal design principles with the following adaptation: socioeconomic equity, cybersecurity and private data protection. The results created a design manual and service as well as policy evaluation tool. The study listed following drivers and barriers to the deployment of inclusive and accessible digital mobility services faced by stakeholders (Base et al. 2023):

Barriers:

- There is no regulatory framework, or it does not address accessibility and inclusion sufficiently.
- Lack of trust between private and public organisations.
- Lack of user involvement and co-creation.
- Lack of knowledge among developers about potential vulnerable-to-exclusion users.
- Unstable market pushes development towards 'typical' users with no or limited inclusive features.
- Limited willingness to share (mobility) related data and information with public authorities and other operators.

Drivers:

- Stable market conditions supported by a comprehensive regulatory framework.
- Integration into the public transport service network where minimum accessibility and inclusivity guidelines have been set.
- Consultation with users and their representatives to have more knowledge of potential users.
- Using inclusive design as a cornerstone of the service development.
- Bottom-up co-creation events.

- Modular approach for the development of services in different areas building in accessibility and inclusivity gradually.
- Open communication with other stakeholders, which includes sharing of information about best/worst practices.
- Local support schemes (subsidies or incentives) to introduce accessibility and inclusiveness features.

Inclusive design perspective on automotive HMI trends has been studied by Bradley et al. (2016). The paper argues that there has been increase in control and display location, interface types and integration and better functionality with new technologies. It is further suggested that increase in interface unfamiliarity cases significant difficulty and possible exclusion. Main reasons of exclusion being learning and conflicts expectations which can have an impact on ageing population and automated driving technologies. According to the study, the following outcomes may occur in future:

- Drivers will be unable to leap into an unfamiliar (such as a rental or loan) vehicle and drive without requiring re-training
- Problematic in situations where the feature is no longer available for the user.
- Useful technology could be implemented in a usable unchallenging way, without causing undue cognitive complexity
- Autonomy would appear to offer both a commercial and humanitarian opportunity to those who struggle with mobility for disability, confidence, capability or for financial reasons.

Automotive HMI International Standards have been presented by Heinrich (2012) where historical reference is made for the PROMETHEUS project in 1985 where Human Factor HMI questions were as well tackled. Heinrich lists in addition to standards, technical reports of warning systems in vehicles and integration of safety-critical and time-critical warning signals. Heinrich (2012) lists following different standards.

Design standards:

1. *Dialog management principles*, where ISO 15005 – general principles of driver system interaction and the respective compliance procedures. The standard was the basis both of the European Statement of Principles (ESoP2006) and of the AAM Guidelines (Alliance of Automotive Manufacturers) (AAM2006)
2. *Visual presentation of information*, where ISO 15008 – defines parameters that are relevant for the safe and quick recognition of visual information.
3. *Auditory presentation*, ISO 15006 – recommendations and requirements for auditory signals.

Performance standards:

1. *Occlusion method to assess visual distraction*, where ISO 16673 describes a method to determine workload.
2. *Simulated lane change test*, where ISO 26022 uses a simplified driving situation.
3. *Detection Response Task*, where ISOO NWI 17588 is to use the subject's reaction to a stimulus and measure whether and how fast the test subject is able to react while operating a device or secondary task.
4. *Measurement of driver visual behaviour*, where ISO 15007 defines different measures and techniques that are important for the evaluation of visual behaviour like glance duration, fixation, transition time and saccade.
5. *Calibration Task*, where ISO TS 14198 is to define tasks that can be reproduced very easily and precisely to allow comparison of results from different labs.

Process standards:

1. *Procedure for assessing suitability for use while driving*, where ISO 17287 describes a process-oriented approach; the following items must be documented.
2. *Procedure for determining priority of messages*, where ISO TS 16951 describes to methods two determine the priority of warnings, the Index Method and the Matrix Method.

The Table 7 below presents literature on s*tandards and guidelines for* related to the inclusive development of ITS and C-ITS services, such as user interfaces. The table should be used as an example of the many standards and guides in the field as several subtasks and design methods as well as standards exists in addition.

Table 7 Standards and guidelines related to the inclusive development of ITS and C-ITS services, such as interfaces.

Standard or guideline related to ITS/C-ITS service inclusive development	Name of the item	Description of the item
ISO 15008:2017	Road vehicles — Ergonomic aspects of transport information and control systems — Specifications and test procedures for in-vehicle visual presentation	Specifies minimum requirements for the image quality and legibility of displays containing dynamic (changeable) visual information presented to the driver of a passenger car by on-board transport information and control systems (TICS) used while the vehicle is in motion.
ISO 9241-11:2018	Ergonomics of human-system interaction. Part 11: Usability: Definitions and concepts	Framework for understanding the concept of usability and applying it to situations where people use interactive systems,
ISO 9241-210:2019	Ergonomics of human-system interaction. Part 210: Human-centred design for interactive systems	Requirements and recommendations for human-centred design principles and activities throughout the life cycle of computer-based interactive systems.
ISO/IEC JTC 1/SC 35	User interfaces	Support for these interfaces to serve all users, including people having accessibility or other specific needs, with a priority of meeting the JTC 1 requirements for cultural and linguistic adaptability.
SAE J2365_201607	Calculation and Measurement of the Time to Complete In-Vehicle Navigation and Route Guidance Tasks	Original Equipment Manufacturer and Aftermarket route-guidance and navigation system functions for passenger vehicles.
NHTSA-2010-0053	Visual-Manual NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Devices	First phase of the NHTSA Driver Distraction Guidelines
NHTSA-2013-0137	Visual-Manual NHTSA Driver Distraction Guidelines for Portable and Aftermarket Devices	Safety framework for developers of portable and aftermarket electronic devices to use when developing visual-manual user interfaces for their systems.
NHTSA DOT HS 812 360	Human Factors Design Guidance For Driver-Vehicle Interfaces (Campbell et al. 2016)	human factors design guidance for driver-vehicle interfaces (DVIs).
ETSI TR 102 762	Human Factors (HF); Intelligent Transport Systems (ITS); ICT in cars	Key aspects of use of ICT in cars and provides advice on safer and more effective use.

World Road Association has also published as a part of Systems and Standards Human Factors, HMI Standards and Guidelines including Design of ITS for Vehicles guidelines. The guidelines include an overview of the RESPONSE project developed code of practice for defining, designing and validating ADAS (Figure 17). (Design for ITS for Vehicles PIARC)

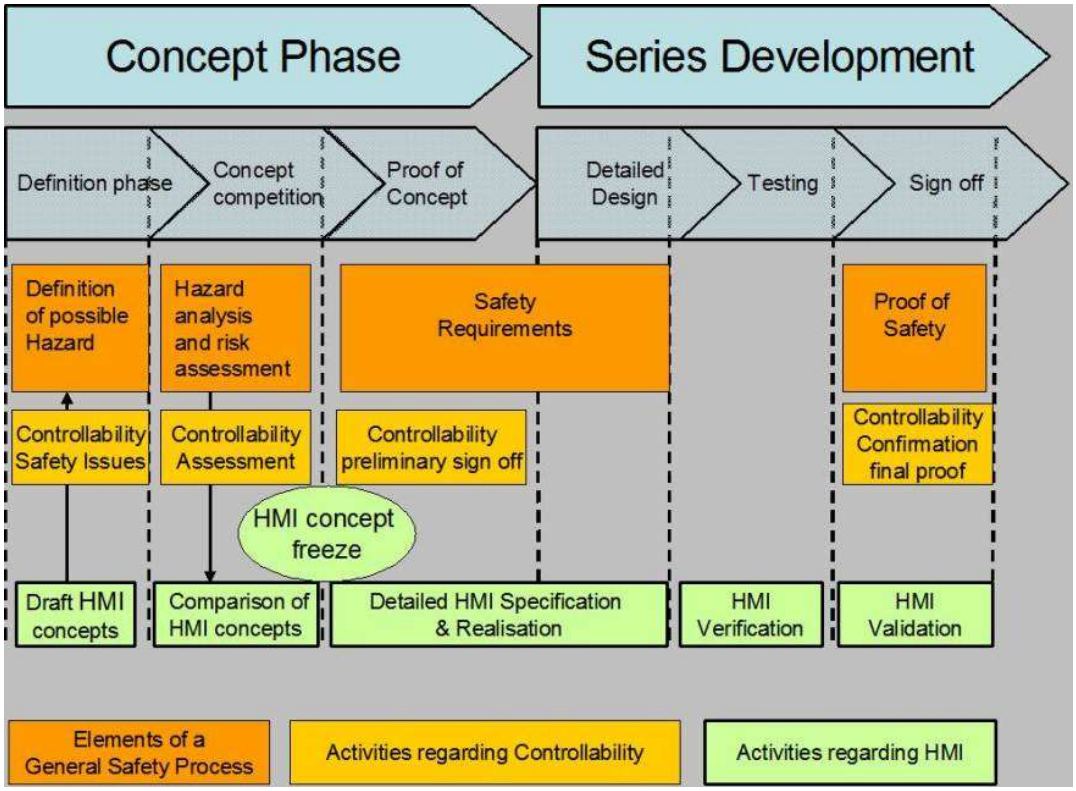

Figure 17 Overview of the RESPONSE code of practice for design of in-vehicle information and assistance systems. (Design for ITS for Vehicles PIARC)

The PIARC guidelines mention that the In-vehicle human factors have several important consequences for Road Network Operations by referring to the following:

- when a Traffic Control Centre exchanges information with vehicles and drivers through Cooperative ITS
- if the network operations include vehicle fleets equipped with information and communication systems, such as mobile safety patrols
- to promote safer travel on their roads
- when the objective is to achieve greater compliance with traffic laws

6.5.3 Workshop and interview results on C-ITS service development

The two workshops in 4th and 5th of November 2025 were both divided into two 45 minutes sections around two stages of traffic information value chain (Figure 11): content and service. This chapter reviews the second service part of the workshop titled as “Development and service provision of ITS and C-ITS services to road users”. Workshops material can be found from APPENDIX 2.

The following were the workshop discussion results categorised in identified topics.

Education of users about services

- Education to users how to use services and how are the services available in the vehicle when you are driving. Basic usage and availability of the services.
- C-ITS or specific information services education of usage responsibility should be with the service providers as aim is ease of use already and instructions created. Maybe some specific cases for authorities and Member States exists, e.g. eCall.

- Service coverage impact on the communication, for example if service penetration rate is 5 %.
- Timing of communication.

Service provision communication

- Transparency: information is visible if you know where to look but not easy to find if published by public authorities. Information should be written for non-experts
- More means of communication is needed, e.g. social media channels, radio, coverage of services (content and services)

Development of services

- Piloting, testing, simulation and modelling together with the user are used and need to understand service needs and requirements, i.e. what are the service quality needs.
- Validation and verification, service metrics, then simulation and verify performance criteria and need for the service. E.g., winter maintenance needs.

Development standards, methodologies and principles

- Less guidance on development as new technologies and services.
- C- ITS is a rather small field of engineering and services. Related to fields of traffic safety and machinery
- Design of fail-safe services that can be utilised and applied in ITS/C- ITS.
- Hard to make changes to mature services, i.e. develop standards early on vs. fast development of services and UIs.
- Different icons/pictograms in user interfaces, e.g. variable message signs which are messages understood better by the road user. Harmonisation done from 90s, EU EIP later, now status is unknown or dropped from development.
- Accessibility recommendations already available for services and should be used.
- Open data principle for the authorities

Legal, (road operator) roles and responsibility

- In SRTI 886/2013 delegated act it is the Member State responsibility to implement service if there is no market availability.
- Product liability: if safety critical information is delayed and non-safety information is presented/prioritised.
- EU legislation of Data act and GDPR.
- Is there a role for government or SRN in ensuring services are safe? Example of a service that highlights areas with no speed cameras or showing adverts to drivers. NHTSA for Europe needed?
- Speed limits example: information delivered to map vs. vehicle camera information. Information might not be updated. RTTI regulation to provide digital information by the road operator.
- Legal aspect of delivering services need to be made
- OEM services need to have the most updated services to users as impact to service reliability.
- System operators are responsible of the service.
    - Underlying principles of the system, e.g. in telco where long evolution and
    - Should be agreed metrics to services performance.

standards engineered

- Road operator role
    - Travel time information from the road operator valuable to users.
    - Some services or part of the service development can concern Member States and authorities, for example eCall services for adapted vehicles of disabled person to send specialised ambulance.
    - Road operator role (depending on Member States) to develop safety
    - and traffic management services. Also support service provision by providing open data.

Business models and priorities

- Incentives to private companies for the market.
- For some services may need to solve the business models and stakeholder. Coordination then required, "chicken and egg problem" (game theory), e.g. eCall where EU required stakeholder coordination
- Vulnerable Road Users (VRU) services are not in forefront of the current C- ITS services as most services are vehicle centred (provision and ethical)
- Easier to develop service gaps where exists than interrupt private market. These gabs should be identified but how?
- Difficult to sell safety as incidents happen rarely, easier to sell comfort.
- Are there gaps where the private sector won't fill in particularly in the safety related services?
- Road operator setting up their own services compared to private industry providing the service, public authority responsibility vs. business models (provision and ethical).

6.5.4 Analysis of the C-ITS service development to road users

The literature and workshops results presented in this chapter indicated that ITS and C-ITS service development includes wide range of industry standards and recommendations that relate to ITS and C-ITS service development from the perspective of legislation, inclusive design and standards.

Legislation requirements for service and HMI development were not directly identified in the study, although as in chapter 4 where legal responsibilities were discussed, the ITS directive sets requirements on safe service delivery. The European Commission HMI recommendations in 2008 can still be considered valid and European accessibility act (EU 2019/882) as well European Union Strategy for the rights of persons with disabilities also relate to HMI development.

Lack of regulatory framework has been identified as barrier (Base et al. 2023) and studies also call government to develop inclusive regulation (Delaere et al. 2024). GDPR, seen complex in the forementioned studies and industry feedback, compliance simplification could also require inclusive design.

Standards, guidelines and recommendations of inclusive service development were further questioned through interviews and comments were requested from the workshop participant to clarify their feedback. HMI expert interviews were also conducted to gather further insight regarding the service development human-centric industry standards and state of the art. These results were included in the previous chapter categories and topics.

The HMI interviews concluded that the vehicle UIs with touch screen have become increasingly more popular. Although in this study standards and guidelines related to ITS/C-ITS service inclusive development was identified, there is still a lack of common standards in vehicle UI

HMI development. UIs are different depending on manufacturer, e.g. presented icons. Empirical testing is done by research and industry organisations. Accessibility guidelines, inclusive design toolboxes and toolkits as well as requirements are used in the service development.

Some examples of inclusive design for transport and mobility were presented in this study such as the DIGNITY project inclusive design toolkit in transport service design, Inclusive Digital Mobility Solutions (INDIMO) and design of in-vehicle information and assistance systems review by PIARC. Some organisations developing services may have internal guidelines for service and UI development.

Concluding the analysis, service and HMI development can be considered difficult when considering requirements of engineering and safety of the user interfaces. Most importantly, the development is required to be made together with the users and with co-creation. Inclusive design on automotive HMI and automotive HMI International standards requires deep knowledge and experience when creating services. From the road operator perspective, best experts are found from the industry where services are developed as co-creation and collaboration between stakeholders was also called in the literature studies.

7 Guidance and recommendations

This chapter suggests guidance and recommendations according to the study's expected outcomes of legal and ethical ramifications for NRAs when making use of C-ITS data, and of how these change the role of the NRA The chapter summaries the main findings from the literature, workshops and interviews. The following recommendations are given and presented below in detail:

1. The NRA should embed legal, contractual and ethical responsibilities for data accuracy in their operation
2. Identify the road users and involve them in communication and real-world development of the services
3. Understand and acquire expertise on C-ITS services, use cases and their limitations
4. Follow inclusive and transparent communication recommendations
5. Develop inclusive services by using the human-centered design principles
6. Apply basic principles and processes for ethical use of data
7. Carry out risk evaluation when communicating and developing ITS/C-ITS services

1. The NRA should embed legal, contractual and ethical responsibilities for data accuracy in their operation

European legislative framework for Intelligent Transport Systems (ITS) is set by the ITS Directive (2023/2661). The ITS Directive requirement for Member States to ensure that where the underlying information already exists, data are made available for geographical coverage for each data type defined in the Directive. These data types can also be exchanged by C-ITS. Requirements for the standards and specifications include C-ITS and safety-related traffic information (which of many C-ITS services are), where the latter includes minimum requirements for the availability and accessibility of accurate data. Therefore, there are no direct technical requirements outside of required data formats (DATEX II, etc.) related to ITS or C-ITS data accuracy nor quality in European legislation. Other ITS and C-ITS relevant European legislation reviews included Product Liability Directive (EU) 2024/2853 that includes software services and related services where traffic data in navigation systems is mentioned as an example of determining the safety of the product just as much as physical or digital components.

Member States are required by legislation to set up National Access Point (NAP), make the data available, communicate inaccuracies (in collaboration), provide parameter of the quality of the data update, and follow minimum quality requirements that are agreed in cooperation with relevant stakeholders (RTTI 2022/670). These are further implemented in the Member State, depending on legislation and policies, by the road operator or National Road Authority (NRA).

When a road operator deploys C-ITS services it follows applicable standards and common European harmonised specifications to achieve cross-border interoperability, the latter being C-Roads Platform if a member. Standards and specifications include or may include in the future minimum requirements for the data accuracy/quality. Public and private parties are working together for example in the Data for Road Safety to find common agreement on data quality requirements. Road operators work together and in collaboration with industry in the C-Road Platform and private industry in TISA for 5 Start Quality Rating to come up with common data quality and evaluation methods.

Road operator responsibility is to manage and evaluate the service and data implementations. The road operator is recommended to employ a data quality management system and process, which would keep the road operator aware of the quality of the data published by it for access

by service providers and/or road users and take up necessary quality enhancement actions when and where necessary. The road operators should also keep the data users aware of the quality of the data published. Finally, commitment to data publication with a specific quality would be good to be made for a specific time period in the future, e.g. until a specific date.

Evaluations should be done from early proof of concepts and pilots to the deployment with possible operational follow-up. Evaluations should include legal and ethical considerations through the data and service life cycle. Evaluation results should be openly and transparently communicated for road users.

It is ethical for the road operator to present and show responsibility by stating clearly, with inclusive communication to different user groups, what are its responsibilities and how does it answer to these responsibilities. Although there was a lack of legal cases on navigation technologies and traffic information responsibility, incidents and accidents related them were reported and these included actions taken by the involved stakeholders to ensure these catastrophic consequences would not repeat.

2. Identify the road users and involve them in communication and real-world development of the services

The road operators are recommended to explicitly specify the road users and other data users targeted by the data published by the road operators. The list of different user groups of this report could be used as a starting point for the selections.

First and foremost, when communicating and developing of ITS services it is crucial to know who the users are and what are their needs; the user engagement should not only be done during the planning phase but all the time in the data and service life cycle.

Road users, or end users, need to be engaged from the very beginning and continuously as a part of the communication and dissemination as well as development process. The following definition of road user has been given in the ITS Directive 2010/40/EU and was used as a basis of the analysis:

> *Road user means motorists such as people driving vehicles, vulnerable road users such as pedestrians and cyclists, road transport infrastructure users and operators, fleet managers and operators of emergency services*

The Table 8 below presents different road users and Table 9 special road user groups with specific communication needs. The road users (or stakeholders) presented in the Table 9 have been adapted from the CEDR DROIDS project report of Soni et al. (2025). The aim of the user grouping or communication needs is not to be extensive but to present the wide range of different user groups who have partly similar but also much different communication requirements and needs, i.e. representing the complex environment of ITS/C-ITS. Part of the examples are more future oriented, like the vulnerable road user services where vehicles and users exchange information, but these were added to present the future communication needs and challenges.

Table 8 Road users with examples of user communication needs. (adapted from the CEDR DROIDS project report of Soni et al. (2025)

Road user / stakeholders	Examples of user communication needs on data accuracy and use of C-ITS systems
Vehicle owner/ driver/ occupant	What is a C-ITS system and service? What systems and services do I have installed on my vehicle? How is the information presented? How do I react when information presented? What information is collected about me and/or my vehicle?
Vulnerable Road Users (VRU), e.g. pedestrians and cyclists	Do vehicles notice me in intersections?
Motorcyclist	How slippery is the road today and how should I interpret the road slipperiness based on the information?
Law enforcement	Is the hazardous location information provided on every accident scene and what is its timeliness? Is my location information secured?
Rescue service provider	Do I have signal priority on every local signalised intersection? What about signalised intersections outside of urban area?
Commercial, delivery, logistic and freight operators	How accurate are the weight/length/width/height restrictions of bridges and tunnels for my special transport? Do I have access to the delivery zone?
Public transport operators	How up to date the road closure information is on my route?
Road infrastructure authority or contractor operating on the road	Does the accident or incidents reported still occur on the road?
Road works or maintenance contractor	How accurately is the location of our roadworks visible to drivers?
Vehicle fleet operator	How accurate is the traffic flow information available?
Vehicle manufacturer and service provider	How real-time and accurate is the traffic and incident data and is it reliable enough to present to our customer road users?
Automated Driving Systems (ADS) provider / ADS	How real-time and accurate is the traffic and incident data that we receive beyond the vehicle sensor horizon?

Table 9 Special road user groups with specific communication needs.

Special road user groups	Examples of user communication needs on data accuracy and use of C-ITS systems
Drivers with disabilities, e.g. hearing	What kind of visual and audio signal guidance do I receive?
Drivers with cognitive impairment or low literacy	How is the information presented and is it clear enough for me?
Elderly	Are the instructions and information easy to understand? Are the digital road signs presented similar as the ones on the roadside infrastructure?
Inexperienced novice drivers	How accurate and reliable is the information?
Children	How do vehicles notice me on the road and intersection?
Pedestrians with disabilities	How do vehicles notice me on the road and intersection?

3. Understand and acquire expertise on C-ITS services, use cases and their limitations

Road operator is recommended to acquire knowledge, expertise and pilot as well as deploy services in collaboration with the market actors to increase understanding of them. This concerns all the study objectives of responsibility, communication and dissemination of data, service development and data ethics.

Each ITS and C-ITS service has unique functional, technical characteristic and data accuracy requirements with different impact to road users. It is crucial for road operator decision-making on data and service communication or development, in addition to working with the road users, to understand each services functionality and impact. Following recommendation examples were presented extracted from the study results to provide an example of the impact on ITS/C-ITS service and use cases for the study objectives:

- Understand services User Interface requirements and impact to road users and road safety when communicating and developing services: study and practice human-centered development methods and best practises to create safe and inclusive services. For example, traffic sign pictograms differ between countries and services while harmonisation of pictograms in the user interfaces would benefit European road users.
- Understand local conditions impact to services when communicating about data and developing services: road friction data quality, which may be part of slippery road services, varies between location, e.g. country, mountains, northern hemisphere, as well as between infrastructure and vehicle sensor inputs and their fusion.
- Understand responsibility, risks and ethical issues between different services: Road works warning service and use cases have limited impact on user data privacy and less risk of ethical issues on implementation. Meanwhile any use case where location data is shared with high frequency, e.g. probe vehicle data (or floating car data) using C-ITS CAM messages, poses risk for unethical use of the data, even if good intensions. Privacy is discussed more in the TIARA project deliverable on Privacy in C-ITS Applications.

4. Follow inclusive and transparent communication recommendations

The main channel for road operator data publication is the National Access Point (NAP), and for the C-ITS data the national or regional interchange nodes or clouds. The road operators should keep the data users aware of the quality of the data published with a simple but widely understood manner recommended below or such as the TISA 5-star rating. The data quality attribute should be mandatory metadata for the data.

The following recommendations are given for road operators on open, transparent and inclusive communication of ITS/C-ITS systems, their data quality and limitations as well as purpose of use for road users with different technical abilities. The main sources presented in the chapter 6.4 include UK Government Data Quality Hub (2021) and second workshop results. Full list of the recommendations with details used in the analysis can be found from APPENDIX 3 of this report, which as well can be used for more detailed communication planning by the road operators.

- Follow legislation, rights and principles
- Explain importance of data quality communication
- Develop effective, bidirectional communication with users and stakeholders
- Make communication user-centric
- Make communication accessible and inclusive
- Practice transparent and reliable data quality and service communication
- Ensure privacy and data protection in communication
- Communicate in a timely and responsive manner
- Engage with data providers and users
- Provide education to users
- Provide communication guidelines for all communication
- Create a process for continuous communication monitoring and development

- Practice proactive risk management in communication

5. Develop inclusive services by using the Human-Centered design principles

ITS and C-ITS service delivery and deployment are mostly done by private industry which compete in the markets for the best services for road users; vehicle user interfaces and mobile devices as well as applications are almost solely developed by OEMs and service providers. Road operator implement services may include services such as roadworks warning or other related to their business case. Digital services like automotive inclusive User Interface development were seen difficult in the literature and workshop results as user needs are complex and diverse while services and their interfaces develop fast. The studies also suggested possible bias on accidents related to navigation technologies, i.e. we only get witness feedback of accidents that the driver and occupants survived. Although challenges, appliance of user-centered design methods support the services development.

Recommendations for road operator when developing ITS/C-ITS services or when evaluating services safety developed by the industry:

- Legislation and regulation related to service development as well as HMIs is not direct nor there are set requirements. ITS Directive (2010/40/EU) defines basic ground for safe services and the European Commission has given earlier recommendations on HMI (2008). Also, European accessibility act (EU 2019/882) and European Union Strategy for the rights of persons with disabilities are related.
- Road operators should follow the industry recommendations of Human-Machine Interfaces development with latest standards and guidelines as well development methods; especially in a situation where road operator implements its own service.
- Road operator responsibility also extends to the agreements and contracts made for example with road maintenance contractors. Legal agreements should for example include ITS and C-ITS service requirements in the road section where road work or maintenance is being carried out, i.e. safe operation of roads for users.
- Barriers and opportunities presented by Delaere et al. (2024) and in the workshops include: governments should develop inclusive regulations, enhance co-creation effort, improve User education and simplify GDPR compliance messaging. Similar and other drivers and barriers were discussed also in the European Horizon INDIMO project.
- Due to the fast pace of development of vehicles user interfaces, close collaboration between road operators, private industry and road users is required to ensure meeting with the user needs and develop inclusive and safe services.
- Development of inclusive services requires extensive piloting, testing, simulation and modelling together with the road users to understand needs and requirements. Validation and verification with service metrics need to be considered.
- Business models and priorities with private companies and in the markets. Possible gaps between services and responsibilities.
- Ethical considerations include road operator role in business models of service deployments; as the private industry sector role is to compete and develop services, market discussion and collaboration should be done to agree where the road operator has a role and interest while not having a negative impact to market business models.

6. Apply basic principles and processes for ethical use of data

Legislation provides the minimum acceptable behaviour for the public and private sector organisations. Ethics and data ethics extend the legislative responsibility by going beyond the

legislation with higher levels of responsibility and accountability.

The basic data ethics principles suggested by Tingley (2021) are recommended for NRAs and road operators as well as organisations that generate and use data in their daily operations. These five principles should be complied to by NRAs as well as the third-party service providers providing data for the NRAs. The four first principles have mainly consequences to the processes for acquiring the data, but the fifth one is the most comprehensive one putting also pressure on data and information quality that was recognised as a crucial ethical aspect in this deliverable.

1. Ownership: Individuals own their personal information. Collecting data without consent is unethical and unlawful. Always obtain permission through clear agreements or policies.
2. Transparency: Be open about how data is collected, stored, and used. Clearly communicate your methods and intentions to data subjects, enabling informed decisions.
3. Privacy: Protect individuals' personally identifiable information (PII) by storing data securely and ensuring it remains confidential. Consider de-identifying datasets to maintain anonymity.
4. Intention: Collect data with a clear, ethical purpose. Avoid gathering unnecessary or sensitive information that doesn't directly serve your project's goals.
5. Outcomes: Assess the potential impact of data analysis. Be vigilant about unintended consequences, such as biases or disparate impacts, and strive to prevent harm to individuals or groups.

Due to the complex environment, the C-ITS pilots and deployments will provide practical and best window to legal and ethical issues and solutions which should be documented and shared in the European collaboration such as C-Roads Platform.

The road operators should also from the data ethics perspective, not only due to legislative or contract requirement, give explicit information about the quality of the data that they provide as open data or traffic information, preferable at the point of use for the data/information. This is turn means that they should also realise the importance of data quality assurance and control processes and commit to setting up and maintaining such processes in a satisfactory manner.

The analysis also recommends the following three strategic, tactical and operational level recommendations for road operators based on ITS and other industries lessons on ethical use of data:

1. Strategic level: Implementation of ITS and C-ITS code of ethics to address ethical values when implementing services and use cases as well as when using data. The code of ethics to comply or use as a basis can also be identified from related fields, such as automotive, telecommunication or information technology.
2. Tactical level: Assigning a responsible member or part of an organisation to introduce the ITS and C-ITS code of ethics in the organisation and handle any questions or issues that may arise in future. This includes whistleblowing, when an issue arises, and decision-making processes for ethical questions. Also, education and training on ethical topics for the employees can be organised as it is the individuals, as a part of team and organisation, who build and implement the services and use of data.
3. Operational level: Use of a framework in new and existing ITS and C-ITS projects to identify any ethical issues. For example, Open Data Institute (ODI) has published a Data Ethics Canvas (2021) to help identify and manage ethical issues in data projects full life-cycle stages when data is collected, shared or used.

7. Carry out risk evaluation when communicating and developing ITS/C-ITS services

Safe and fluent traffic requires risk management and evaluation from the road operator. Risks should be evaluated in the full traffic information value chain from content provisioning to service provisioning and communicated to road users. Risk evaluation during service pilots and deployments can raise possible ethical questions and issues related to use of data, data quality, communication and dissemination and service development. Aim is also to minimise risk of financial or reputational damage, which may impact on service implementations and usage. Poor quality of data needs to be communicated to prevent misuse and bigger risks for the users; it is not always known what information is useful for the users.

Communication risk management is further discussed in the above recommendation number 4. The CEDR PRESORT project discusses further third-party data and risks related to it, for example acquisition and procurement related to the services (Laine et al. 2025). The TIARA project deliverables on PKI Guidance Development and Privacy in C-ITS Applications, e.g. misuse of personal data, will also in their part reflect the mitigation of risks.

Following risks were identified in the study regarding responsibility, communication and dissemination as well as service development, and recommended to be evaluated. These risks also provide example of type of risks included in ITS/C-ITS communication and service development:

- Weather information and especially detailed location information about slippery road conditions can be difficult to communicate as different interpretation and trust experiences.
- Avoidance of legal responsibility risk can lower interest of service providers and authorities for providing data.
- Liability and responsibility, also ethical, when a data provider shares inaccurate data poses a question whether the provider knew about the poor data quality, and/or the possible inaccuracies and risk involved with it and still decided to send the data.
- Analyse data and services negative effects on people and communicate potential harm or risks.
- Consider risks of exclusion associated with the development of ITS and C-ITS services. Policy recommendations to address these risks have been provided for example in the DIGNITY project presented in chapter 6. The project for example recommends enhancing dissemination strategies and diversify communication channels.
- Data life cycle should include careful preparation, storing and maintaining of the data to prevent risk of lack of informative metadata.
- Missing road characteristics data contributed to over 24% of Death by GPS incidents. Study recommendations outlined “space usage rule” mapping, incorporating weather information in routing, and improving visual and audio instructions in complex situations.

8 Conclusions

The objective of TIARA project's Work Package 3 (WP3) Legal and Ethical Aspects was to review the legal and ethical ramifications for NRAs when making use of C-ITS data, and of how these change the role of the NRA. Conclusions related to the six study objectives are summarised below. The role of road operator or National Road Authority (NRA) is discussed as a part of the conclusions.

1. Guidance on the responsibility of the road authority to ensure that data is accurate, and the accountability when inaccurate data is sent.

European legislative framework for Intelligent Transport Systems (ITS) is set by the ITS Directive (2023/2661). The ITS Directive requirement for Member States to ensure that where the underlying information already exists, data are made available for geographical coverage for each data type defined in the Directive. These data types can also be exchanged by C-ITS. Requirements for the standards and specifications include C-ITS and safety-related traffic information (which of many C-ITS services are), where the latter includes minimum requirements for the availability and accessibility of accurate data.

Therefore, there are no direct technical requirements outside of required data formats (DATEX II, etc.) related to ITS or C-ITS data accuracy nor quality in European legislation. However, Member States are required by legislation to set up NAP, make the data available, communicate inaccuracies (in collaboration), provide parameters of the quality of the data update, and follow minimum quality requirements that are agreed in cooperation with relevant stakeholders (RTTI 2022/670). These are further implemented in the Member State, depending on legislation and policies, by the road operator or National Road Authority (NRA).

When a road operator deploys C-ITS services it should follow the applicable standards and common European harmonised specifications to achieve cross-border interoperability (C-Roads); these standards and specifications include or may include in the future minimum requirements for the data accuracy/quality.

Other ITS and C-ITS relevant European legislation was reviewed and among the C-ITS specific legislation (draft delegated act in 2019), protection of personal data, security, open data and liability for defective products, the latter stands out. The Product Liability Directive (EU) 2024/2853 includes software services and related services where traffic data in navigation systems is mentioned as an example of determining the safety of the product just as much as physical or digital components.

2. Guidance on best practice for the communication of data and its limitations with road users

The most important aspect is to know who the users are and what are their needs; the users need to be consulted throughout data and service development life cycle. The following definition of road user has been given in the ITS Directive 2010/40/EU and was used as a basis of the analysis:

> *Road user means motorists such as people driving vehicles, vulnerable road users such as pedestrians and cyclists, road transport infrastructure users and operators, fleet managers and operators of emergency services*

The road operators are recommended to explicitly specify the road users and other data users targeted by the data published by the road operators. The list of different user groups of this report could be used as a starting point for the selections.

The main channel for data publication is the NAP, and for the C-ITS data the national or

regional interchange nodes or clouds. The road operators should also keep the data users aware of the quality of the data published with a simple but widely understood manner such as the TISA 5-star system. The data quality attribute should be mandatory metadata for the data.

Further guidance on communication of data and its limitations to road users is provided in the next research questions of 3. and 4. where especially point "Recommendations when communicating about data content and quality".

3. Views on how to be open and transparent with roads users on the use of data was combined with the research objective **4. Review of how communications around the use of C-ITS systems and data can be ensured to be inclusive of road users across technical ability.**

The road operators are recommended to address the following aspects for transparent and inclusive communication – mainly based on UK Government Data Quality Hub (2021) and workshop results:

- Follow legislation, rights and principles
- Explain importance of data quality communication
- Develop effective, bidirectional communication with users and stakeholders
- Make communication user-centric
- Make communication accessible and inclusive
- Practice transparent and reliable data quality and service communication
- Ensure privacy and data protection in communication
- Communicate in a timely and responsive manner
- Engage with data providers and users
- Provide education to users
- Provide communication guidelines for all communication
- Create a process for continuous communication monitoring and development
- Practice proactive risk management in communication

Research objective **4.** was separately studied to give **guidance on developing C-ITS services that are inclusive of road users across technical abilities**

ITS/C-ITS service development can be approached from two perspectives: industry and road operator service development. Today, the industry does most of the service development. Whether road operator develops its own services or monitors the inclusiveness of industry developed services, the following conclusions were made:

- Road user technical abilities need to be reflected in the HMI and human-factor user interface development. Inclusive, universal and usability principles can be used to make systems easy to use for all users so that the users can reach their task goal. These principles and best practices were referred in the study chapter 6.5.2 "Service development industry standards, guidelines and recommendations" and should be followed in collaboration with the industry.
- Legislation and regulation related to service development as well as HMIs is not direct nor there are set legislative requirements. Indirect legislative references can be identified in the ITS Directive (2010/40/EU) that defines basic ground for safe services. The European Commission gave recommendations for safe and efficient in-vehicle information and communication systems (2008). Although in-vehicle systems have developed considerably after the recommendations, they are still valid, and the recommendations can be applied.

- Road operator responsibility on services also extends to the agreements and contracts made for example with road maintenance contractors. As an example, if a contractor has been required to use a service or third-party application as a part of a road works, the service usability need to be ensured by the road operator.
- Barriers and opportunities presented in the literature and in the workshops included simplifying GDPR compliance messaging, lack of inclusive regulation, and enhancement of co-creation. Especially the latter co-creation requires close collaboration between road operators, private industry and road users to ensure the user needs are met to develop inclusive and safe services. Although it was identified that there was lack of inclusive or HMI regulation, the study results did not provide evidence for a need of a such regulation as its upsides and downsides should be further considered, in collaboration with the industry.
- Development of inclusive services requires extensive piloting, testing, simulation and modelling in conjunction with the road users to understand user and service needs and requirements. Validation and verification with service metrics also need to be considered. If a road operator decides to develop its own services, these requirements need to be understood with careful considerations and has to evaluate, whether the service and use case development is a priority part of its core business. Risks need to be addressed when using multisided business models with the industry as this could lead to high development and maintenance costs. Possible gaps between services and road operator responsibilities can be evaluated when deciding, including also ethical considerations.

5. Lessons from other industries on the ethical use of data

Data ethics principles and actions proposed in the UK government Data Ethics Framework (2020) are recommended as guidance for the road operators and contractors working for them. This framework has both overarching principles and specific actions. The overarching principles of transparency, accountability and fairness are applicable across the entire process. The specific actions guide through different stages of the road operator operations and provide practical considerations.

C-ITS pilots and deployments will provide practical and best insight to the legal and ethical issues and solutions which should be documented and shared with the community.

It is ethical for the road operators to provide open data while at the same time sharing openly their responsibilities and data quality.

Ethical questions and issues depend on the type of ITS and C-ITS service and use case which differ per situation. For example, use of road works data differs from probe vehicle data that includes location data. Additionally, digital traffic rules and regulations as well as traffic sign data can include ethical questions for data accuracy and responsibility, especially when used in context of automated driving.

The study gives three strategic, tactical and operational level recommendations for road operators based on ITS and other industries lessons on ethical use of data which include implementation of code of ethics and its implementation at an organisational level.

6. Analysis of the information about road users that could be leaked from C-ITS data and the potential impact on the data subject.

This research objective was mainly studied in the TIARA deliverable on Privacy in C-ITS Applications (Maerivoet 2025). This study covered and concluded the following from the objective:

- Data and services delivered by the NRA or its subcontractors, will be the responsibility of the NRA.
- Inclusive communication requires that a wide range of user groups are identified and based on the recommendations this study informed as to privacy measures of the delivered services and their impact.
- It is ethical to communicate risks and possible leaks that may have occurred to the road users with potential impacts and the recommended actions to mitigate those impacts. The recommended ethical process established in the organisation and following the recommended data ethic principles in this study, will help to establish the NRA data ethics policy.

The following seven guidance and recommendations for the future given for the road operators based on the six research objectives and expected output results.

1. The NRA should embed legal, contractual and ethical responsibilities for data accuracy in their operation
2. Identify the road users and involve them in communication and real-world development of the services
3. Understand and acquire expertise on C-ITS services, use cases and their limitations
4. Follow inclusive and transparent communication recommendations
5. Develop inclusive services by using the Human-Centered design principles
6. Apply basic principles and processes for ethical use of data
7. Carry out risk evaluation when communicating and developing ITS/C-ITS services

The study's limitations include insufficient expert feedback on the ethical matters. The participation rate of ITS experts in the project workshops was much lower than for the other work packages in the TIARA project. While road operators and research and academia representatives were reasonably active in their participation, private industry representative feedback was much harder to receive. Both two workshops and separate email surveys included ethical questions and issues with a request on internal or external guidelines used, but such were not received. This might be due to the nature of ITS being a small subdomain in engineering lacking such specific guidelines and low awareness of the ethical guidance used in the other technological domains. It could also be that ethics is not among the most urgent priority issues in the domain of ITS as in most cases ethics is built in the rules and regulations complied to in the development and deployment of ITS and thereby also C-ITS.

Inclusive service development considering users technical abilities and Human-Machine Interface recommendations were mainly limited to literature with only little feedback from the workshops and field experts.

References

About C-ITS | CAR 2 CAR Communication Consortium. (n.d.). Retrieved 16 March 2024, from https://www.car-2-car.org/about-c-its

ACM (2025). 'The Code Affirms an Obligation of Computing Professionals to Use Their Skills for the Benefit of Society.' Retrieved 10 January 2025 (https://www.acm.org/code-of-ethics).

Action Plan and Directive—European Commission. (n.d.). Retrieved 24 March 2024, from https://transport.ec.europa.eu/transport-themes/intelligent-transport-systems/road/action-plan-and-directive_en

Adams, Janet S., Armen Tashchian, and Ted H. Shore (2001). 'Codes of Ethics as Signals for Ethical Behavior'. Journal of Business Ethics 29(3):199–211. doi: 10.1023/A:1026576421399.

arsTECHNICA (2023). Google sued over fatal Google Maps error after man drove off broken bridge. Retrieved 25 February 2025. https://arstechnica.com/tech-policy/2023/09/lawsuit-says-man-died-after-google-maps-directed-him-over-collapsed-bridge/#:~:text=Tragic%20map%20mistake-,Google%20sued%20over%20fatal%20Google%20Maps%20error%20after%20man%20drove,for%20years%20despite%20correction%20requests.&text=Google%20is%20being%20sued%20by,bridge%20in%20Hickory%2C%20North%20Carolina

Article 8—Protection of personal data. (2015, April 25). European Union Agency for Fundamental Rights. http://fra.europa.eu/en/eu-charter/article/8-protection-personal-data

Australian Government. 2024. 'Codes of Conduct'. Business.Gov.Au. Retrieved 10 January 2025 (https://business.gov.au/legal/fair-trading/codes-of-conduct).

Autoevolution (2024). Popa, B. (2024, November 28). Google Maps Navigation Ends Tragically After Three Men Drive off Unfinished Bridge. Autoevolution. https://www.autoevolution.com/news/google-maps-navigation-ends-tragically-after-three-men-drive-off-unfinished-bridge-243404.html

Autoevolution (2025). Popa, B. (2025, March 5). Google Maps Navigation Blamed for Another Tragedy, Car Plunges Into 30-Feet-Deep Drain. Autoevolution. https://www.autoevolution.com/news/google-maps-navigation-blamed-for-another-tragedy-car-plunges-into-30-feet-deep-drain-247997.html

Bagloee, S. A., Tavana, M., Asadi, M., & Oliver, T. (2016). Autonomous vehicles: Challenges, opportunities, and future implications for transportation policies. Journal of Modern Transportation, 24(4), 284–303. https://doi.org/10.1007/s40534-016-0117-3

Basu, S., Delaere, H., Keseru, I., Ciommo, F. D., & Rondinella, G. (2023). Ensuring inclusive and accessible digital mobility through universal design. Transportation Research Procedia, 72, 2732–2737. https://doi.org/10.1016/j.trpro.2023.11.814

BBC (2024). Google, Apple and TomTom make sat-nav changes after Milton Keynes crash. (2024, November 4). https://www.bbc.com/news/articles/c1dp40kpvzdo

Bo, Brinkman, Flick Catherine, Gotterbarn Don, Miller Keith, Vazansky Kate, and J. Wolf Marty. (2017). 'Dynamic Technology Challenges Static Codes of Ethics: A Case Study'. The ORBIT Journal 1(2):1–16. doi: 10.29297/orbit.v1i2.37.

Bradley, M., Langdon, P. M., & Clarkson, P. J. (2016). An Inclusive Design Perspective on Automotive HMI Trends. In M. Antona & C. Stephanidis (Eds.), Universal Access in Human-Computer Interaction. Users and Context Diversity (pp. 548–555). Springer International Publishing. https://doi.org/10.1007/978-3-319-40238-3_52

C-ITS Point of Contact. (n.d.). Retrieved 16 March 2024, from https://cpoc.jrc.ec.europa.eu/

Campbell, J. L., Brown. J. L., Graving, J. S., Richard, C. M., Lichty, M. G., Sanquist, T., … & Morgan, J. L.. (2016, December). Human factors design guidance for driver-vehicle interfaces (Report No. DOT HS 812 360). Washington, DC: National Highway Traffic Safety Administration. https://www.nhtsa.gov/sites/nhtsa.gov/files/documents/812360_humanfactorsdesignguidance.pdf

CC BY 4.0 Legal Code | Attribution 4.0 International | Creative Commons. (n.d.). Retrieved 30 March 2024, from https://creativecommons.org/licenses/by/4.0/legalcode.en#s6b

C-Roads TF2. C-ITS Service and Use Case Definitions Version 2.2.1. C-Roads Platform Working Group 2 Technical Aspects. Taskforce 2 Service Harmonisation.

Chaufton, S. (2023, December 7). Successful TISA RTTI Data Quality Workshop in Amsterdam. TISA. https://tisa.org/successful-tisa-rtti-quality-workshop-in-amsterdam/

ChatGPT. Model (GPT-4-turbo). Summaries made be ChatGPT-4 were verified by the author. https://chatgpt.com/.

CINEA 2023. Towards Cooperative, Connected and Automated Mobility. Contributions of Horizon Europe projects managed by CINEA. European Commission. https://www.ccam.eu/wp-content/uploads/2023/05/HE-CCAM-2023_brochure-web-FIN.pdf

Clavell, G. G., & Peuvrelle, V. (2020). Ethical Issues in Big Data Analytics for Time Critical Mobility Forecasting. In G. A. Vouros, G. Andrienko, C. Doulkeridis, N. Pelekis, A. Artikis, A.-L. Jousselme, C. Ray, J. M. Cordero, & D. Scarlatti (Eds.), Big Data Analytics for Time-Critical Mobility Forecasting (pp. 343–358). Springer International Publishing. https://doi.org/10.1007/978-3-030-45164-6_12

COMMISSION DELEGATED REGULATION (EU) …/... Supplementing Directive 2010/40/EU of the European Parliament and of the Council with Regard to the Deployment and Operational Use of Cooperative Intelligent Transport Systems (201 C.E.). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=PI_COM%3AC%282019%291789

Commission Delegated Regulation (EU) 2015/962 of 18 December 2014 Supplementing Directive 2010/40/EU of the European Parliament and of the Council with Regard to the Provision of EU-Wide Real-Time Traffic Information Services (Text with EEA Relevance), 157 OJ L (2014). http://data.europa.eu/eli/reg_del/2015/962/oj/eng

Commission Delegated Regulation (EU) No 886/2013 of 15 May 2013 Supplementing Directive 2010/40/EU of the European Parliament and of the Council with Regard to Data and Procedures for the Provision, Where Possible, of Road Safety-Related Minimum Universal Traffic Information Free of Charge to Users Text with EEA Relevance, 247 OJ L (2013). http://data.europa.eu/eli/reg_del/2013/886/oj/eng

Cooperative, connected and automated mobility (CCAM)—European Commission. (n.d.). Retrieved 16 March 2024, from https://transport.ec.europa.eu/transport-themes/intelligent-transport-systems/cooperative-connected-and-automated-mobility-ccam_en

CORDIS – EU research results. 'Inclusive Mobility: Building Sustainable Transportation Systems Accessible to All'. CORDIS | European Commission. Retrieved 18 February 2025 (https://cordis.europa.eu/article/id/445570-inclusive-mobility-building-sustainable-transportation-systems-accessible-to-all).

Council of Europe. (2023). Code of Conduct. https://rm.coe.int/code-of-conduct/1680a97549

Cremers, Anita H. M., Mark A. Neerincx, and Jacomien G. M. de Jong. (2013). 'Inclusive Design: Bridging Theory and Practice'. Pp. 323–32 in Engineering Psychology and Cognitive Ergonomics. Applications and Services, edited by D. Harris. Berlin, Heidelberg: Springer.

https://link.springer.com/chapter/10.1007/978-3-642-39354-9_35

Davis, Michael (1991). 'Thinking Like an Engineer: The Place of a Code of Ethics in the Practice of a Profession'. Philosophy & Public Affairs 20(2):150–67. https://www.researchgate.net/profile/Michael-Davis-52/publication/330942065_Thinking_Like_an_Engineer/links/5ca4a8bda6fdcc12ee8fc497/Thinking-Like-an-Engineer.pdf

Davis, Michael (2016). Thinking Like an Engineer: The Place of a Code of Ethics in the Practice of a Profession. Philosophy & Public Affairs, Vol. 20, No. 2 (Spring, 1991), pp. 150-167. Wiley. http://www.jstor.org/stable/2265293

Data Ethics Framework (2020): Glossary and methodology. (n.d.). GOV.UK. Retrieved 28 August 2024, from https://www.gov.uk/government/publications/data-ethics-framework/data-ethics-framework-glossary-and-methodology

DataONE Best Practices Working Group, DataONE (Aug 30, 2011) "Best Practice: Communicate data quality". Accessed through the Data Management Skillbuilding Hub at https://dataoneorg.github.io/Education/bestpractices/communicate-data-quality on Mar 01, 2024

Delaere, Hannes, Samyajit Basu, Cathy Macharis, and Imre Keseru. (2024). 'Barriers and Opportunities for Developing, Implementing and Operating Inclusive Digital Mobility Services'. European Transport Research Review 16(1):67. doi: 10.1186/s12544-024-00684-8. https://etrr.springeropen.com/articles/10.1186/s12544-024-00684-8

Delegated regulation—2022/670—EN - EUR-Lex. (n.d.). Retrieved 24 March 2024, from https://eur-lex.europa.eu/eli/reg_del/2022/670/oj

Delegated regulation—EU monitor. (n.d.). Retrieved 30 March 2024, from https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vkh7cp7t4km6

Design of ITS for Vehicles | RNO/ITS - PIARC (World Road Association). (n.d.). Retrieved 25 February 2025, from https://rno-its.piarc.org/en/systems-and-standards-human-factors-hmi-standards-and-guidelines/design-its-vehicles

DIGNITY project. 'Home'. DIGNITY. Retrieved 12 February 2025 (https://www.dignity-project.eu/).

DIGNITY Toolkit. Retrieved 12 February 2025 (https://dignity-toolkit.eu/).

DIGNITY Final recommendations. Retrieved 12 February 2025 (https://dignity-toolkit.eu/wp-content/uploads/2022/12/Final-Recommendations.pdf).

Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the Framework for the Deployment of Intelligent Transport Systems in the Field of Road Transport and for Interfaces with Other Modes of Transport Text with EEA Relevance, CONSIL, EP, 207 OJ L (2010). http://data.europa.eu/eli/dir/2010/40/oj/eng

Directive—2024/2853—EN - EUR-Lex. (n.d.). Liability for defective products. Retrieved 11 June 2025, from https://eur-lex.europa.eu/eli/dir/2024/2853/oj/eng

DROIDS (2023). Digital Road Operator Information and Data Strategy, CEDR. https://www.cedr.eu/docs/view/65a1754ac20ce-en

European Union (2019). Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information (recast). https://eur-lex.europa.eu/eli/dir/2019/1024/oj

European Union (2023). Directive (EU) 2023/2661 of the European Parliament and of the Council of 22 November 2023 amending Directive 2010/40/EU on the framework for the

deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport. https://eur-lex.europa.eu/eli/dir/2023/2661

DO-IT, University of Washington. 'What Is the Difference between Accessible, Usable, and Universal Design? | DO-IT'. Retrieved 13 January 2025 (https://www.washington.edu/doit/what-difference-between-accessible-usable-and-universal-design).

Eke, Damian, and Bernd Stahl (2024). 'Ethics in the Governance of Data and Digital Technology: An Analysis of European Data Regulations and Policies'. Digital Society 3(1):11. doi: 10.1007/s44206-024-00101-6.

Emma, Lawrence. 2024. 'User-Centered Design to Enhance Accessibility and Usability in Digital Systems'. https://www.researchgate.net/publication/386339454_User-centered_design_to_enhance_accessibility_and_usability_in_digital_systems

ERTICO (2025). 30th ITS World Post-Congress Report. Dubai ITS World Congress 16-20 September 2024. 96 p. https://itsworldcongress.com/wp-content/uploads/2025/01/ITS-Dubai-2024-Full-Post-Congress-Report.pdf?_gl=1*10a6b4w*_gcl_au*Mjk4NDgzNTc5LjE3Mzk3ODgxODk.*_ga*MTA5NjM3MzEwLjE3Mzk3ODgxODk.*_ga_4VZT8CZF8M*MTczOTc4ODE4OS4xLjAuMTczOTc4ODE4OS42MC4wLjIwNDY0OTgxNzQ.*_ga_YLRBM643RY*MTczOTc4ODE4OS4xLjAuMTczOTc4ODE4OS42MC4wLjYwOTI1Mzc0NA..

Erwin, Patrick M. (2011). 'Corporate Codes of Conduct: The Effects of Code Content and Quality on Ethical Performance'. Journal of Business Ethics 99(4):535–48. doi: 10.1007/s10551-010-0667-y.

Martinho, A., Herber, N., Kroesen, M., & Chorus, C. (2021). Ethical issues in focus by the autonomous vehicles industry. Transport Reviews, 41(5), 556–577. https://doi.org/10.1080/01441647.2020.1862355

Ethics4EU (2022). European Values for Ethics in Digital Technology. https://ascnet.ie/wp-content/uploads/2022/01/14.-European-Values-for-Ethics-in-Digital-Technology-FINAL-EDIT.pdf

ETSI HF. 'Human Factors (HF) and Accessibility'. ETSI. Retrieved 17 February 2025 (https://www.etsi.org/technologies/human-factors-accessibility).

ETSI TR 102 762 v1.1.1 (2010-04). Human Factors (HF); Intelligent Transport Systems (ITS); ICT in cars. Technical report. https://www.etsi.org/deliver/etsi_tr/102700_102799/102762/01.01.01_60/tr_102762v010101p.pdf

EU EIP (2022). C-ITS Quality package. EU EIP SA 4.1: Determining Quality of European ITS Services. Version 1.0. January 21, 2022. https://www.its-platform.eu/wp-content/uploads/ITS-Platform/AchievementsDocuments/Quality%20Frameworks/EU%20EIP%204.1_C-ITS%20Quality%20Package%20v1.0_20220121.pdf

European Union (2016). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility. COM/2016/0766 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016DC0766

EU 2019/882. Anon. 2019. Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the Accessibility Requirements for Products and Services (Text with EEA Relevance). Vol. 151. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019L0882

European Commission (2008). Commission Recommendation of 26 May 2008 on safe and efficient in-vehicle information and communication systems: update of the European Statement of Principles on human-machine interface. https://eur-lex.europa.eu/eli/reco/2008/653/oj

European Commission European accessibility act. (2025). 'European Accessibility Act – European Commission'. Retrieved 19 February 2025 (https://commission.europa.eu/strategy-and-policy/policies/justice-and-fundamental-rights/disability/union-equality-strategy-rights-persons-disabilities-2021-2030/european-accessibility-act_en).

European Commission (2021). Union of equality: Strategy for the rights of persons with disabilities 2021-2030. https://commission.europa.eu/strategy-and-policy/policies/justice-and-fundamental-rights/disability/union-equality-strategy-rights-persons-disabilities-2021-2030_en

European Commission (2020). Ethics of Connected and Automated Vehicles. Recommendations on road safety, privacy, fairness, explainability, and responsibility. Directorate-General for Research and Innovation. https://op.europa.eu/en/publication-detail/-/publication/89624e2c-f98c-11ea-b44f-01aa75ed71a1/language-en

European Data Protection Supervisor (2025). 'Ethics | European Data Protection Supervisor'. Retrieved 11 January 2025 (https://www.edps.europa.eu/data-protection/our-work/ethics_en).

European Data Protection Supervisor (2025). '#DebatingEthics Conversation 1: The Relationship between Ethics and the Law | European Data Protection Supervisor'. Retrieved 11 January 2025 (https://www.edps.europa.eu/debatingethics-conversation-1-relationship-between-ethics-and-law).

European Union 2021. Directorate-General for Employment, Social Affairs and Inclusion (European Commission). 2021. Union of Equality: Strategy for the Rights of Persons with Disabilities 2021 2030. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/3e1e2228-7c97-11eb-9ac9-01aa75ed71a1/language-en ; https://commission.europa.eu/strategy-and-policy/policies/justice-and-fundamental-rights/disability/union-equality-strategy-rights-persons-disabilities-2021-2030_en

European Union COM/2020/66 (2020). A European Strategy for Data. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0066

European Union 2022/868 (2022). Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European Data Governance and Amending Regulation (EU) 2018/1724 (Data Governance Act) (Text with EEA Relevance). Vol. 152. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R0868

Eutelsat. Code of Ethics. https://www.eutelsat.com/files/PDF/group/Eutelsat_Code_Of_Ethics.pdf

Federal Ministry of Transport and Digital Infrastructure (2017). Ethics Commission. Automated and Connected Driving. Report June 2017. https://bmdv.bund.de/SharedDocs/EN/publications/report-ethics-commission.pdf?__blob=publicationFile

Federal Ministry of Transport and Digital Infrastructure (2017). Ethics Commission. Automated and Connected Driving. Report (EXTRACT) June 2017. https://www.bmdv.bund.de/SharedDocs/EN/publications/report-ethics-commission-automated-and-connected-driving.pdf?__blob=publicationFile

Fisk, A.D., Rogers, W.A., Charness, N., Czaja, S.J., Sharit, J.: Designing for older adults: principles and creative human factors approaches, 2nd edn. Human Factors & Aging Series. CRC Press Taylor & Francis Group, Boca Raton (2009)

Floridi, L., & Taddeo, M. (2016). What is data ethics? Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 374(2083), 20160360. https://doi.org/10.1098/rsta.2016.0360

Government Data Quality Framework (2021). GOV.UK. Retrieved 14 January 2025 (https://www.gov.uk/government/publications/the-government-data-quality-framework/the-government-data-quality-framework).

Government Data Quality Hub (2021). 'The Importance of Communicating Data Quality'. GOV.UK. Retrieved 14 January 2025 (https://www.gov.uk/government/news/the-importance-of-communicating-data-quality).

Government Data Quality Hub (2021). 'The Government Data Quality Framework: Case Studies'. GOV.UK. Retrieved 14 January 2025 (https://www.gov.uk/government/publications/the-government-data-quality-framework/the-government-data-quality-framework-case-studies).

Government Data Quality Hub (2021). 'The Government Data Quality Framework: Guidance'. GOV.UK. Retrieved 14 January 2025 (https://www.gov.uk/government/publications/the-government-data-quality-framework/the-government-data-quality-framework-guidance).

Guo, R., Vallati, M., Wang, Y., Zhang, H., Chen, Y., & Wang, F.-Y. (2023). Sustainability Opportunities and Ethical Challenges of AI-Enabled Connected Autonomous Vehicles Routing in Urban Areas. IEEE Transactions on Intelligent Vehicles, 1–4. https://doi.org/10.1109/TIV.2023.3345661

Heinrich, C. (2012). „Automotive HMI - International Standards". https://www.researchgate.net/publication/280530786_Automotive_HMI_-_International_Standards

Herschel, R., & Miori, V. M. (2017). Ethics & Big Data. Technology in Society, 49, 31–36. https://doi.org/10.1016/j.techsoc.2017.03.003

Holmner, M. (n.d.). Intelligent Transport Systems: Privacy, security and societal considerations within the Gauteng case study E Hommes and M Holmner.

Juan Pablo Hourcade (2008), "Interaction Design and Children", Foundations and Trends® in Human–Computer Interaction: Vol. 1: No. 4, pp 277-392. http://dx.doi.org/10.1561/1100000006

IBE 2025. n.d. 'Code of Ethics'. Retrieved 10 January 2025 (https://www.ibe.org.uk/knowledge-hub/ibe-business-ethics-framework/code-of-ethics.html).

IEEE. 'IEEE Code of Ethics'. Retrieved 10 January 2025 (https://www.ieee.org/about/corporate/governance/p7-8.html).

Inclusive design research centre. 'Philosophy'. Inclusive Design Research Centre. Retrieved 13 January 2025 (https://idrc.ocadu.ca/about/philosophy/).

Inclusive design research centre. 'Inclusive Design Research Centre'. Retrieved 13 January 2025 (https://legacy.idrc.ocadu.ca/about-the-idrc/49-resources/online-resources/articles-and-papers/443-whatisinclusivedesign).

Interaction Design. What is User Experience (UX) Design? (n.d.). The Interaction Design Foundation. Retrieved 25 February 2025, from https://www.interaction-design.org/literature/topics/ux-design

ISO 8000-1:2022(en), Data quality—Part 1: Overview. (n.d.). Retrieved 17 March 2024, from https://www.iso.org/obp/ui/#iso:std:iso:8000:-1:ed-1:v1:en

ISO 8000-2:2022(en), Data quality—Part 2: Vocabulary. (n.d.). Retrieved 17 March 2024, from

https://www.iso.org/obp/ui/#iso:std:iso:8000:-2:ed-5:v1:en:term:3.8.9

ISO 15008:2017. (n.d.). ISO. Retrieved 25 February 2025, from https://www.iso.org/standard/62784.html

ISO 25012. (n.d.). Retrieved 17 March 2024, from https://iso25000.com/index.php/en/iso-25000-standards/iso-25012

ISO 9000:2015(en), Quality management systems—Fundamentals and vocabulary. (n.d.). Retrieved 17 March 2024, from https://www.iso.org/obp/ui/fr/#iso:std:iso:9000:ed-4:v1:en:term:3.6.2

ISO 9241-11:2018. ISO. Retrieved 13 January 2025 (https://www.iso.org/standard/63500.html).

ISO 9241-210:2019. (n.d.). ISO. Retrieved 25 February 2025, from https://www.iso.org/standard/77520.html

ISO/IEC 25012:2008(en), Software engineering—Software product Quality Requirements and Evaluation (SQuaRE)—Data quality model. (n.d.). Retrieved 17 March 2024, from https://www.iso.org/obp/ui/#iso:std:iso-iec:25012:ed-1:v1:en

ISO/IEC JTC 1/SC 35—User interfaces. (2009, December 11). ISO. https://www.iso.org/committee/45382.html

ISO Accessibility for all. 2021. 'Accessibility for All'. ISO. Retrieved 17 February 2025 (https://www.iso.org/news/ref2612.html).

ITU. 'Ethics'. Retrieved 10 January 2025 https://www.itu.int:443/en/ethics/pages/default.aspx.

ITU-T (2013). FG Distraction—Report on Vehicle-to-Applications Communications Interface. (n.d.). https://www.itu.int/dms_pub/itu-t/opb/fg/T-FG-DISTRACTION-2013-4-PDF-E.pdf

J2365_201607: Calculation and Measurement of the Time to Complete In-Vehicle Navigation and Route Guidance Tasks—SAE International. (n.d.). Retrieved 25 February 2025, from https://www.sae.org/standards/content/j2365_201607/

Kotilainen I., Scholliers J., Öörni R. & Kulmala R. The roles of the authorities in the implementation and operational use of Cooperative Intelligent Transport Systems (C-ITS) services. Original report in Finnish language. Finnish Transport and Communication Agency Traficom publication 23/2023. https://www.traficom.fi/sites/default/files/media/file/C-ITS-roolit_raportti_final.pdf

Krishnamurthy, P. (2011). An Introduction to Ethics (SSRN Scholarly Paper 1781502). https://doi.org/10.2139/ssrn.1781502

Krontiris, I., Grammenou, K., Terzidou, K., Zacharopoulou, M., Tsikintikou, M., Baladima, F., Sakellari, C., & Kaouras, K. (2020). Autonomous Vehicles: Data Protection and Ethical Considerations. Computer Science in Cars Symposium, 1–10. https://doi.org/10.1145/3385958.3430481

Laine, T., Kostiainen, J., Schirokoff, A., Lubrich, P, Öörni, R., Kusters, M., Leiro, G., Mechin, J-P., Buraga, C., Dyreborg, S., Ryström, L., Antola, P., Barr, J., Metzner, S., Homolka, F. & Niculescu, M. Work towards Optimum Quality of ITS. Final report. EU EIP SA 4.1: Determining Quality of European ITS Services. Version: 1.0. Date: 12th February 2021.

Laine, T., Isoranta V., Kulmala, R. & Kotilainen I. (2025). PRESORT: WP5 Conclude report. Version 1.0. Date 04/17/2025. Final report.

Laine T., Kulmala R. & Isoranta V. (2025). Data procurement models. Unpublished draft deliverable version. CEDR PRESORT project.

Liability for defective products—European Commission. (n.d.). Retrieved 11 June 2025, from https://single-market-economy.ec.europa.eu/single-market/goods/free-movement-sectors/liability-defective-products_en

Lin, A. Y., Kuehl, K., Schöning, J., & Hecht, B. (2017). Understanding 'Death by GPS': A Systematic Study of Catastrophic Incidents Associated with Personal Navigation Technologies. Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, 1154–1166. https://doi.org/10.1145/3025453.3025737

Madiega T. (2019). 'EU Guidelines on Ethics in Artificial Intelligence: Context and Implementation'.

Maerivoet S. (2025). Possible gaps between services and responsibilities. Deliverable D8. CEDR TIARA project. Unpublished draft report. Version 0.2. 11 October 2024.

Mańko, R. (n.d.). Understanding delegated and implementing acts.

Martinho, A., Herber, N., Kroesen, M., & Chorus, C. (2021). Ethical issues in focus by the autonomous vehicles industry. Transport Reviews, 41(5), 556–577. https://doi.org/10.1080/01441647.2020.1862355

Merriam Webster. 2025. 'Definition of CODE OF ETHICS'. Retrieved 10 January 2025 (https://www.merriam-webster.com/dictionary/code+of+ethics).

Michigan Tech. What is Human Factors? (n.d.). Michigan Technological University. Retrieved 25 February 2025, from https://www.mtu.edu/psychology/undergraduate/human-factors/what/

NAPCORE | National Access Point Coordination Organisation for Europe. (2024, February 1). https://napcore.eu/

NAPCORE Quality (2025). Quality Online Repository. 2 May 2025. Page updated on March 26, 2025. https://napcore.eu/quality/

NC State University. 'Center for Universal Design'. College of Design. Retrieved 13 January 2025 (https://design.ncsu.edu/research/center-for-universal-design/).

Nielsen, Jakob. 1994. Usability Engineering. Morgan Kaufmann.

NIST. Editor, CSRC Content. n.d. 'Usability - Glossary | CSRC'. Retrieved 13 January 2025 (https://csrc.nist.gov/glossary/term/usability).

Norman, D. A. (2013). The Design of Everyday Things. Revised and Expanded Edition. Basic Books.

Open Data Institute (ODI) (2021). 'The Data Ethics Canvas'. The ODI. Retrieved 11 January 2025 (https://theodi.org/insights/tools/the-data-ethics-canvas-2021/).

Ordinary legislative procedure. (n.d.). European Parliament. Retrieved 30 March 2024, from https://www.europarl.europa.eu/infographic/legislative-procedure/index_en.html

PMI (2012). 'Leader's Choice - Five Steps to Ethical Decision Making'. Retrieved 10 January 2025 (https://www.pmi.org/learning/library/leaders-choice-ethical-decision-making-6031).

Posey, B. M. (2023). The final destination: Incorporating 'Death by GPS' into forensic and legal sciences. Science & Justice, 63(3), 421–426. https://doi.org/10.1016/j.scijus.2023.04.005

PRESORT (2023). Improving the use of Third-Party Data by NRAs, CEDR. https://www.cedr.eu/docs/view/66855f271003b-en

Responsibilities and Policy | Road Safety Manual—World Road Association (PIARC). (n.d.). Retrieved 30 March 2024, from https://roadsafety.piarc.org/en/planning-design-operation/responsibilities-and-policy

Retscher, G. (n.d.). An Appeal to Discuss Ethical Issues in Context with Cooperative User Localization.

Santoni de Sio, F. (2021). The European Commission report on ethics of connected and automated vehicles and the future of ethics of transportation. Ethics and Information Technology, 23(4), 713–726. https://doi.org/10.1007/s10676-021-09609-8

Schwartz M. S. (2002). 'A Code of Ethics for Corporate Code of Ethics - ProQuest'. Retrieved 10 January 2025 (https://www.proquest.com/openview/55862082e1badab6193dbd44f59f1686/1?pq-origsite=gscholar&cbl=6472).

Silva, R., & Iqbal, R. (2019). Ethical Implications of Social Internet of Vehicles Systems. IEEE Internet of Things Journal, 6(1), 517–531. https://doi.org/10.1109/JIOT.2018.2841969

Soni, S., Chaudhary, R., Alkim, T., Kotilainen, I. & Kulmala, R. (2025). D2.1 State of the Art of Digital Twins for Road Infrastructure and D3.1 Digital Twin State of the Art – Technical Aspects. Digital Road Operator Information and Data Strategy (DROIDS) project, CEDR Call 2022 Data. Unpublished draft report.

Supina, S. & Elm D. (2019). 'Ethics as a Process'. Business Ethics Resource Center. Retrieved 10 January 2025 (https://www.businessethicsresourcecenter.org/ethical-decision-making-process-2/).

Tingley D. (2021). '5 Principles of Data Ethics for Business'. Business Insights Blog. Retrieved 28 August 2024 (https://online.hbs.edu/blog/post/data-ethics).

Technical Standards to achieve Data Quality | datos.gob.es. (n.d.). Retrieved 17 March 2024, from https://datos.gob.es/en/blog/technical-standards-achieve-data-quality

The Data Ethics Canvas. (2019, July 3). The Open Data Institute (ODI). https://theodi.org/news-and-events/blog/data-ethics-canvas/

Traveller Information Services Association (TISA) (2016). Position on Quality of Traffic Information. https://tisa.org/wp-content/uploads/QWG16001_TISA_Position_paper_Quality_Of_Traffic_Information_v12a_final.pdf

TISA (2024). EU RTTI 5-Star Rating. Follow up Workshop Hybrid in Brussels/Online 12 March 2024. Presentation. 44 p. https://tisa.org/wp-content/uploads/TISA-RTTI-Data-Quality-Workshop_Brussels_slides_draft_proposal.pdf

Tisa, S. L., Tisa, S. L., & Tisa, M. U. (n.d.). 4. Updated Use Cases • Speed Limits • Planned/Unplanned Road Works • Planned/Unplanned Road Closures 5. Outlook & Next Steps.

Transposition—EUR-Lex. (n.d.). Retrieved 30 March 2024, from https://eur-lex.europa.eu/EN/legal-content/glossary/transposition.html

Types of EU law—European Commission. (n.d.). Retrieved 30 March 2024, from https://commission.europa.eu/law/law-making-process/types-eu-law_en

UC Berkeley (2019). Your Navigation App Is Making Traffic Unmanageable. Retrieved 25 February 2025. https://its.berkeley.edu/news/your-navigation-app-making-traffic-unmanageable

UK Finance (2025). 'UK Legislation and the Need for Data Ethics Principles'. UK Finance. Retrieved 11 January 2025 (https://www.ukfinance.org.uk/news-and-insight/blogs/uk-legislation-and-need-data-ethics-principles).

UK Government Digital Service and Central Digital and Data Office. (2024). 'Understanding

Accessibility Requirements for Public Sector Bodies'. GOV.UK. Retrieved 18 February 2025 (https://www.gov.uk/guidance/accessibility-requirements-for-public-sector-websites-and-apps).

University of Cambridge (0222). 'Inclusive Design Tooolkit. About This Project'. Retrieved 10 February 2025 (https://www.inclusivedesigntoolkit.com/transport_about/).

University of Pittsburgh (2024). 'Business Ethics: Importance of Business Ethics in Law'. Pitt Law MSL Online Program. Retrieved 11 January 2025 (https://online.law.pitt.edu/blog/business-ethics-and-law).

van der Pijl, D.J., Cremers, A.H.M., Soede, M.: Personalized PDA accessibility for intellectually disabled persons: concept guidelines based on the development of an electronic travel companion. In: HCI International, Las Vegas, July 22-27 (2005)

Visual-Manual NHTSA Driver Distraction Guidelines for Portable and Aftermarket Devices. (2016, December 5). Federal Register. https://www.federalregister.gov/documents/2016/12/05/2016-29051/visual-manual-nhtsa-driver-distraction-guidelines-for-portable-and-aftermarket-devices

W3C Accessibility Standards Overview. Initiative (WAI), W3C Web Accessibility. n.d. 'W3C Accessibility Standards Overview'. Web Accessibility Initiative (WAI). Retrieved 14 February 2025 (https://www.w3.org/WAI/standards-guidelines/).

WebAIM. Cognitive disabilities Part 1 (We Still Know Too Little, and We Do Even Less) and Part 2 (Conceptualizing Design Considerations). Web Accessibility In Mind, http://webaim.org/articles/cognitive

WHO. 2025. Code of Ethics and professional conduct. Referred on 9 January 2025. https://www.who.int/docs/default-source/documents/ethics/code-of-ethics-pamphlet-en.pdf

Your Navigation App Is Making Traffic Unmanageable | Institute of Transportation Studies. (n.d.). Retrieved 18 March 2024, from https://its.berkeley.edu/news/your-navigation-app-making-traffic-unmanageable

Zhankaziev, S., Gavrilyuk, M., Morozov, D., & Zabudsky, A. (2018). Scientific and methodological approaches to the development of a feasibility study for intelligent transportation systems. Transportation Research Procedia, 36, 841–847. https://doi.org/10.1016/j.trpro.2018.12.068

APPENDIX 1 Workshop May 2024 material

Presentation material of the TIARA workshop 7th of May 2024 session on data accuracy and road operator responsibilities. The material below includes draft results and questions within the research frameworks five elements.

1. European legal framework

Reviewed European legislation

Directive and delegated acts

- Directive of Intelligent Transport Systems (ITS) (2023/2661)
- Delegated Regulation (EU) No 886/2013... road safety-related minimum universal traffic information...
- Delegated Regulation (EU) 2022/670 of 2 February 2022... EU-wide real-time traffic information services
- Other?

Other C-ITS relevant European legislation

- Draft (not in force) C-ITS delegated act (C/2019/1789)
- GDPR
- Open data directive 2019/1024
- Other?

From legislation and hypotheses

- There are no direct technical requirements outside of required data formats (DATEX II, etc.) related to C-ITS or ITS data quality nor quality in European legislation.
- However, Member States are required by legislation to set up NAP, make the data available, communicate inaccuracies (in collaboration), provide parameter of the quality of the data update and follow minimum quality requirements that are agreed in cooperation with relevant stakeholders (Directive 2023/2661, RTTI 2022/670).
- When a road operator deploys C-ITS services it follows applicable standards and common European harmonised specifications to achieve cross-border interoperability (C-Roads):
  - these standards and specifications include or may include in the future minimum requirements for the data quality.
  - Possible upcoming regulation for C-ITS in Europe.

2. Member States national legislation and policies

National legislation

- European Union regulations, delegated acts, are applicable throughout the Member States. Directives implemented in national laws.
- National laws can include road operator tasks and responsibilities.
- Government has the main national responsibility through the road operator.

Questions

- Member states national legislation use case examples available on road operator data accuracy responsibility?
- Awareness and views on the recommendations from NAPCORE, EU EIP, TISA?
- Other?

3. Member States and authorities' contractual agreements and incentives

Agreements and incentives

- **Service Level Agreements (SLAs)** are signed between the road authorities and traffic information service providers to agree on delivered quality of data – agreements are not disclosed due to nature of contracts.
- **Open data** offered by the road authorities can also include terms of use.
- **Data for Road Safety** is the European Safety Related Traffic Information (SRTI) Ecosystem.
- **The Traveller Information Services Association (TISA)** has introduced five-star quality rating for real-time traffic information (RTTI)

Questions

- **SLA** examples between traffic information service providers and road operators?
- Examples of road operators and public authorities **open data** related quality statement/commitment or data use recommendations?
- Any experiences related to the use of **Data for Road Safety** ecosystem, TISA or similar other data quality recommendations?
- Other?

4. Authorities and industry views on data usage and responsibilities

Examples of feedback received by far

- Lack of feedback about the data usage can make it difficult for the road operator to assess the data accuracy.
- Terms of use and license agreements limit liabilities of road operator.
- European legislation is vague on data quality or accuracy, but several initiatives ongoing between European public and private stakeholders (e.g., NAPCORE, DFRS, TISA).

Questions

- Use cases and previous experiences on data usage and responsibilities?
- Experiences about open data quality?
- Experiences of road operators or OEM and service providers paid data feeds and their data quality? Does free (open data) feed quality differ from paid data feed?
- Terms of use experiences from industry?
- Does your organisation use ethical guidelines? If yes, what ethics aspects does it cover?

5. Case studies and legal case decisions

Example use cases received

- Data provided might not be critical to third parties, but rather data that may be used for information purposes.
- Lack of trust to road operator data by OEMs and service providers due to possible legal liability issues.
- United States has ongoing Google Maps legal case about inaccurate data provision as a cause of an accident.
- Navigation apps (re)routing traffic to unwanted routes, roads or streets.

Questions

- Any case studies or legal case decisions about data accuracy or quality?

APPENDIX 2 Workshops November 2024 material

Presentation material of the TIARA workshops in 4th and 5th of November 2024 on "Ethical ITS/C-ITS content and service provision to users".

1. Conclusions of the first interim results on road operator responsibility for data accuracy

- Intelligent Transport Systems **(ITS) Directive (2023/2661)** and related delegated acts set the **European legislative framework with minimum requirements** for the availability and accessibility of accurate data.
- **There are no direct technical requirements** outside of required data formats (DATEX II, etc.) related to ITS and C-ITS **data accuracy nor quality** in European legislation.
- However, **Member States are required by legislation** to set up National Access Point, make the data available, communicate inaccuracies (in collaboration, e.g. NAPCORE), provide parameter of the quality of the data update, and follow minimum quality requirements that are agreed in cooperation with relevant stakeholders. (EU RTTI 2022/670, EU SRTI 886/2013)
- **Requirements are further implemented** in the Member State, depending on legislation and policies, by the road operator or National Road Authority. These requirements also include for example contractual agreements, standards and industry requirements.

2. Workshop: Ethical ITS/C-ITS content and service provision to users

Value chain	Topic	Data ethics
1. Content	Communication and dissemination of road operator data content to users	Ethical considerations
2. Service	Development and service provision of ITS and C-ITS services to road users	Ethical considerations

3. A short Introduction to data ethics

- **Ethics** involves learning what is right or wrong, and doing the right thing where the ethical dilemmas arise.
- **Data ethics** is a branch of ethics that studies moral problems and good moral solutions as well as evaluates data practices with the potential to adversely impact on people and society – in data collection, sharing and use as well as data, algorithms and corresponding practices. (Open Data Institute; Floridi & Taddeo 2016)
- **Legislation** such as data protection, safety and security include ethical aspects.

Floridi & Taddeo (2016). What is data ethics? https://doi.org/10.1098/rsta.2016.0360
Open Data Institute. The Data Ethics Canvas. https://theodi.org/news-and-events/blog/data-ethics-canvas/

4. Communication and dissemination of road operator ITS/C-ITS data content to users

Communication and dissemination of road operator ITS/C-ITS data content to users

- **Users who are communicated?** For example, road users, traffic information and service providers. Users with different technical abilities must be known to define further requirements for the communication and dissemination.
- **What content is communicated to users?** For example, data limitations, regulation and prioritisation.
- **How are users communicated?** For example, organisational aspects, transparency and language.
- **When the communication to users is done?** For example, knowledge about data issues and timing.
- **Where the communication should be done to users?**, For example, how to reach the audience and communication channels.

Ethical questions
Ethical considerations or issues when communicating and disseminating data content to users in ITS or other industries?
Is it ethical to provide **inaccurate information** when we are fully aware that it is inaccurate?
What **European regulation and policies** could be related to ethical data communication and dissemination?
Does your organisation have, or have you observed elsewhere **ethical guidelines, code of ethics or other similar guidance** related to data content communication?

5. Development and service provision of ITS and C-ITS services to road users

Development and service provision of ITS and C-ITS services to road users

Traffic information and C-ITS service provision mainly done by the industry.

- What is the role of road operator?
- What are road operator service provision needs and who are the users and their requirements?
- How to ensure inclusive ITS/C-ITS services for road users across technical abilities?
- Is there a lack of industry standards, recommendations and design principles today for ITS and C-ITS service development and provision to road users? What is the role of road operator?
- What use cases road operators have had on service provision? Issues or success stories on service provision?

Ethical questions
Ethical considerations or issues when developing and provisioning of services to users?
Is it ethical if it is known that **service provisioning has issues** and not have common standards or requirements in place?
What **European regulation and policies** could be related to ethical service development and service provision?
Does your organisation have, or have you observed elsewhere **ethical guidelines, code of ethics or other similar guidance** related to development and provisioning of services?

APPENDIX 3 Inclusive and transparent communication recommendations from literature and workshops

This appendix includes full list of recommendations that were collected for road operators on open, transparent and inclusive communication of ITS/C-ITS systems, their data quality and limitations as well as purpose of use for road users with different technical abilities. The data collection and analysis of the recommendations is presented in chapter 6. The analysis concluded the following recommendations:

- Follow legislation, rights and principles
- Explain importance of data quality communication
- Develop effective, bidirectional communication with users and stakeholders
- Make communication user-centric
- Make communication accessible and inclusive
- Practice transparent and reliable data quality and service communication
- Ensure privacy and data protection in communication
- Communicate in a timely and responsive manner
- Engage with data providers and users
- Provide education to users
- Provide communication guidelines for all communication
- Create a process for continuous communication monitoring and development
- Practice proactive risk management in communication

Follow legislation, rights and principles

- Regulation requirements must be met
- Safety Related Traffic Information (SRTI) delegated regulation (EU 886/2013): provide free of charge SRTI for everyone and collaborate with the private industry for example in the Data for Road Safety (SRTI) ecosystem.
- Fundamental rights of European Union chapter of "right to live", i.e. everyone has the right to the protection of personal data concerning him or her.
- Authorities to follow open data principle, which includes content and service provision.
- Follow European Accessibility act (EU 2019/882) directive and its requirements for product and service development transposed to national laws, with including other possible national and Member State legislation.

Explain importance of data quality communication

- Communicate why the data quality matters, for example traffic safety and vision zero of traffic safety in Europe.
- Demonstration of strengths and limitations of your data so that users may decide if useful for them.
- Providing fuller picture of data and its journey to add openness and transparency for the quality and use of data.
- Mitigate against people using the data for wrong purposes and therefore risk of safety issues and costs.
- Minimise risk of financial or reputational damage
- Give users confidence in the data and use of it.
- Promote and maintain confidence and integrity of your organisation.
- Poor quality of data needs to be communicated to prevent misuse and bigger risks. Might be usable to some but unknown if not communicated.

- Fulfilling requirements of legislation is not the main reason for communication, but certainly one of the important responsibilities of public authority.

Develop effective, bidirectional communication with users and stakeholders

- Develop effective communication channels with and between stakeholders to ensure a broad understanding of data quality and to reach wide audience.
- Develop feedback channels to get feedback on data quality.
- Make it easy for users to report issues.
- Social media communication accuracy and reliability can be questioned; therefore, road operator communication can provide facts, and if needed, correct false statements.

Make communication user-centric

- Communicate clearly and in plain language, following relevant style guides for published materials
- Provide clear definitions of terminology used and not presume a high level of user understanding of data quality
- Make sure that data bias is communicated to your users.
- Assess how different road user groups reach more detailed information as specific issue may concerns different uses and data.
- Consider how communication evolves for different user groups by time, for example automated driving and automated driving systems as well as their creators.
- Provide further learning and resources

Make communication accessible and inclusive

- Use inclusive communications template(s)
- Provide accessible by default resources
- Sign Language guidance
- Use standard wording for communications briefs
- Offer possibility to join accessibility community
- Use inclusive language: words to use and avoid when writing about disability
- Portraying disability guidelines for communication
- Use a range of communication channels to reach disabled people
- Use accessible communication formats

Practice transparent and reliable data quality and service communication

- Flag data quality issues
- Give scores to your data quality and/or use other industry recommendations, e.g. TISA 5-star rating.
- Describe the quality control methods
- Describe standards or test data used for the quality analysis.
- When derived data sets are created: include the percent flagged data and percent missing data in the metadata
- Communicate data attributes that can enhance quality of service, for example if a vehicle is registered as adapted vehicle for e.g. disabled person, special ambulance can be sent.
- Present data limitations and inaccuracies
- Inform if any deviations from the terms of agreements in place
- Inform if any known changes to the data
- Inform if any warnings or caveats to data

- Provide background of the data, e.g. parties involved collecting the data, stage of lifecycle.
- Provide not only communication about the data set but relation to other data and system level understanding.
- Provide clear data quality information and describe its impact on use of the data
- Communicate trade-offs in data quality clearly to aid understanding of the data's strengths and weaknesses
- Be transparent about the quality assurance approach taken and communicate data quality issues clearly to users
- Inform users in advance about changes made to data processes which could impact on quality
- Communicate trade-offs to the users of your data to avoid ambiguity and misuse of the data.
- Include details in the communication such as data field or metadata in concern.
- Prioritise and classify clearly what is important and severe, e.g. colour coding of important sections or data.

Ensure privacy and data protection in communication

- Provide data protection and privacy knowledge and information, e.g. end user consent: what is required, what is being shared? Is it personal data?
- Consider privacy issues when asking questions from the user.

Communicate in a timely and responsive manner

- Evaluate timing and timeliness of the communication, for example RTTI delegated act refers to real- time communication, i.e. as soon as happening should be informed. Incidents can be old if not automatically deleted or cleared in communication when their time limit not yet passed.
- RTTI delegated act states that data quality issues should be acknowledge in relevant time.
- Inform any cuts in service or downtime of services in timely manner

Engage with data providers and users

- Proactively engage with data providers to ensure a clear understanding of data quality requirements
- Communicate any changes in data quality to stakeholders at all stages of the data lifecycle
- Build strong relationships with suppliers of external data to identify data quality problems at source.
- Consider if data or information created by users to road operators is available and could be used as a part of the communication, i.e. user feedback. Give credit (to road users) where it belongs.
- C-ITS pilots implemented and funded by road operators should provide knowledge and disseminate about quality, reliability, ethical and legislation matters openly. C-ITS pilot quality levels defined during the pilot should be disseminate to public or road users.

Provide education to users

- Consider tacit and explicit knowledge of data, for example GPS location and similar inaccuracies in data quality is common knowledge when learned in practice but not known by everyone and has an impact on service use safety and quality.
- Consider always how can you communicate data quality, so users understand the implications
- Evaluate and consider how inaccurate data is understood by the users, e.g. slippery road; when does the data come inaccurate, how bad the quality will need to be? What can be measured?
- Communicate differences between data content and service provision as they can relate and/or separate from each other, e.g. data quality of road surface and weather condition impacts the use and experience of service.
- Let users know how they can use services, and data, and if they have the services available, for example in C-ITS only those who have the C-ITS-station in their vehicle/device can receive the C-ITS service messages.

Provide communication guidelines for all communication

- Offer multilanguage support to different language user groups, e.g. if multiple official languages by legislation and larger groups living in a Member State.
  Use clear and understandable, i.e. accessible, language of communication
- Offer documentation and share metadata to minimise ambiguity and enhance opportunity for data access and reuse. NAP includes metadata but not perhaps on quality. Document and report data quality issues and be transparent about steps being taken to address them
- Provide FAQs for basic knowledge.
- Have common language on what is being communicated, same to everyone everywhere across Europe and not only limited to experts.

Create a process for continuous communication monitoring and development

- Analyse why something went wrong and prevent same problem occurring again to improve.
- Create organisational policy, strategy and/or process, e.g. “policy on informing users of data accuracy”.
- Embed effective data management and governance: Data practitioners should ensure that measuring, communicating and improving data quality is at the forefront of activities relating to data.
- Build data quality capability: dedicate time and resource to building capability in assessing, improving and communicating data quality through training and sharing best practice
- Data quality information sheet with possible tailoring for different societal and road operator business needs
- Information hub for updates available and roadmap for delivery across services
- Evaluate and create metrics of the communication of data, i.e. what is critical for communication and costs acceptable.

Practice proactive risk management in communication

- Not all future problems can be predicted. Where possible, anticipate and prevent future data quality issues through good communication, effective management of change and addressing quality issues at source.
- Regularly communicate with users to keep up with changing data and quality requirements
- Ensure metadata and other supporting documentation is thorough and up to date
- Offer other sources or mitigation to users if issues