



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



Digital Road Operator Information and Data Strategy
(DROIDS)

Data Strategy for the digital road operator

D5.2 A roadmap for implementing the data
strategy

4th of September 2025





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Executive summary

This data strategy roadmap for the digital road operator is the final deliverable and results from the CEDR-funded DROIDS project, aiming to provide both road operators and CEDR with guidance on their journey to become digital road operators. The roadmap outlines a set of actions to enable data as an asset across various areas of road operations, aligning with the European Data Strategy.

The methodology of the DROIDS project applied the Digital Transformation Framework (DTF) and included, in addition to the digital road infrastructure, two other CEDR Call 2022 Data projects: PRESORT on third-party data and TIARA on trustworthy and secure data infrastructure. The data strategy roadmap builds on the results of the three mentioned projects.

The methods used in the study included a literature review, collaboration with road operators and private industry experts, as well as a workshop. **Validation** of the proposed roadmap actions was evaluated by the DROIDS work package leaders, road operators, and the DROIDS Advisory Group, which included public, private, and industry members.

The data strategy roadmap results include 11 action categories, which further comprise 15 actions for the digital road operators. The following paragraphs summarise the action categories and actions included for road operators, CEDR, and specific actions concerning the European Data Spaces.

The following **seven high-priority action categories for road operators** were proposed in the roadmap:

1. **Provide education and enhance skills.** Tailored training programs and practical competency development using pilots, proof of concept and real-life use cases. Also, collaboration with educational institutions.
2. **Implement interoperability and utilise standards.** Actively involved in the implementation of International and EU standards to achieve interoperability.
3. **Carry out stakeholder collaboration and prioritise use cases.** Develop a stakeholder strategy with a use-case-driven stakeholder engagement plan.
4. **Develop and purchase data and services in accordance with established standards, guidelines, and design principles.** Treat data as a raw material with well-defined attributes and procurement processes. Use human-centric design principles and co-creation.
5. **Develop a data governance and risk management framework.** Agree on a data governance framework that safeguards, among other things, data quality, compliance, privacy, security, data diversity, stakeholder-led audits and ethics.
6. **Implement a change management process.** Implement a change management process that supports new processes, organisational changes, or the adoption of technologies to ensure a smooth transition and acceptance.
7. **Implement a trust framework.** Monitor PKI infrastructure to detect technical and security issues. Use the EU C-ITS PKI to allow for effective C-ITS data exchange across borders.

The following **high-priority action category for the Conference of European Directors of Roads (CEDR)** was proposed in the roadmap:

8. **Establish appropriate CEDR actions to support road operators**, such as establishment of needed skills for road operators and contractors, identification of the most important digital representation use cases and their types, ensure road operators embed in addition to legal also contractual and ethical responsibilities for

data accuracy, use of open standards, definition of road operators role in the European mobility data space, development of digitalisation strategy.

The following **three high-priority action categories for specific actions for the Common European Mobility Data Space (EMDS)** were proposed in the roadmap:

9. **Implement an EMDS-compliant data space supporting digital road operations.** Follow the step-by-step approach outlined in the Co-Creation Method (Appendix 6.5), as provided by the DSSC and the Data Spaces Design Principles (Appendix 6.4).
10. **Formalise the standards to be applied for digital road operations** as a data space "vocabulary service" that acts as a central repository for standardised data models and their documentation, enabling semantic interoperability.
11. **Implement a data governance framework and a data governance body.** Utilise recommendations proposed for the Common European Mobility Data Space, agree on a rulebook (governance model) for the data space, and establish a data governance body for digital road operations.

The priority of actions should be analysed based on the goals and business objectives of the road operator organisation and the current digital road operation maturity level. A holistic approach to trust should be applied in the actions.

Most of the actions were directed to the road operators. The actions directed to CEDR were fewer but still important, as several key actions and decisions by road operators require support from CEDR-initiated activities, including the sharing of best practices, identification of key digital representation use cases, and guidance to ensure trust in road operator data, among others.

The validity of the results was affected by feedback from road operators and the varying levels of digital maturity among them. Other limitations of the study include the ongoing evolution of the data landscape, the limited knowledge of data space competence among the participating road operators, and restrictions on documenting data sources. Additionally, there are many technical and business development areas related to digital road operation that the three CEDR projects—DROIDS, PRESORT, and TIARA—did not address. These include, for example, specific service-dependent digital infrastructure developments, Service Level Agreements (SLAs), and data analysis capabilities.

DROIDS project description

DROIDS is a CEDR Transnational Road Research Programme Call 2022 project, aiming to provide road operators, including European National Road Authorities (NRAs), with increased knowledge and support to reap optimal benefits from digitalisation as they evolve into digital road operators managing the physical, operational, and digital road infrastructures. As digital road operators, they will provide better road user services while enhancing the safety, efficiency, and sustainability of road transport.

The background of this research is the ongoing transformation of road operators into digital road operators, who are responsible for operating both physical and digital road infrastructure. Some road operators have already developed their processes and services accordingly, while some are still reflecting on the developments and discussing the transformation.

First, the project will examine the changing roles of road operators as they transition into digital road operators. Special focus is given to the new roles introduced by digital road operation, while anticipated changes to existing roles are also addressed. DROIDS pays particular attention to the evolution of these roles across different CEDR member countries, which currently have varying levels of digital maturity.

Secondly, the project examines the evolution of digital twins from road data banks to comprehensive, real-time digital twins of the road transport system, encompassing infrastructure, traffic, land use, and the road environment. Here, the integration of digital twins with the processes and tasks in the road operator's core business is thoroughly assessed.

Thirdly, trust has been identified as the key attribute for road operator-originated data/information concerning its use by private sector stakeholders such as vehicle manufacturers and service providers. Thereby, DROIDS also highlights the issues related to ensuring trust and security in the maintenance, sharing, and use of the digital road infrastructure.

Finally, the work of DROIDS concludes in the production of an overarching data strategy for the physical and digital road operators, taking on board the results from DROIDS and other ongoing projects (such as CEDR Data Call 2022 PRESORT and TIARA projects).

Expected achievements and benefits to road operators:

- DROIDS provides road operators with a clearer understanding of the prerequisites and roles associated with becoming a digital road operator, which is vital for those considering this transition.
- It emphasises the crucial step for road operators: adapting processes to maximise benefits from digital tools.
- While DROIDS provides insights for process adaptation, the actual implementation must align with each road operator's unique digital and organisational maturity.
- The project results will outline specific recommendations regarding actions and roles tied to HD maps, electronic traffic, and transport regulations, aiding road operators in decision-making

Glossary

ADS	Automated Driving Systems
AIM	Asset Information Modelling
BIM	Building Information Modelling
C-ITS	Cooperative Intelligent Transport Systems
CEDR	Conference of European Directors of Roads
DIM	Deconstruction information model
DROIDS	Digital Road Operator Information and Data Strategy project funded by CEDR
DT	Digital Twin
EC	European Commission
EU	European Union
GNSS	Global Navigation Satellite System
IoT	Internet of Things
NRA	National Road Authority. NRA is often used in Europe. This study uses a term “road operator” that also includes NRAs.
ODD	Operational Design Domain
OTL	Object Type Libraries
PIARC	World Road Association
PIM	Project Information Model
SOTA	State-of-the-Art
TRL	Technology Readiness Levels

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1 Introduction

1.1 Introduction to the research and roadmap

Road operators, including the National Road Authorities (NRAs) and road managers in Europe, are pursuing benefits from digitalisation as they evolve to become digital road operators with responsibilities, amongst others, to operate the physical, operational and digital road infrastructures. As digital road operators, they should be able to provide better road user services while improving the safety, efficiency, and sustainability of road transport. To do so, increased knowledge and experience are necessary among the full spectrum of digital possibilities.

To effectively utilise digital twins as a tool for digital road operations and simulation, it is essential to understand which phenomena are relevant to safe, efficient, and sustainable road operations that can be represented digitally. These representations require relevant models and access to high-quality data provided by different providers.

Several priority areas for digitalisation of road operations were identified in the DROIDS project, including asset management, electronic traffic regulations, road works, incident detection, access control/UVAR, including road tolls, general regulations, and CCAM – distributed ODD awareness. As data becomes a meta-utility for road operations, several challenges need to be addressed, such as ensuring data privacy and security, dealing with interoperability issues, navigating complex legal and regulatory environments, overcoming organisational silos, addressing issues of trust, and mitigating the risk of loss of control over shared data.

The following figure outlines the CEDR DROIDS project Data strategy and roadmap deliverables, i.e. including this deliverable, overview and content. The content is further explained in the following paragraphs.

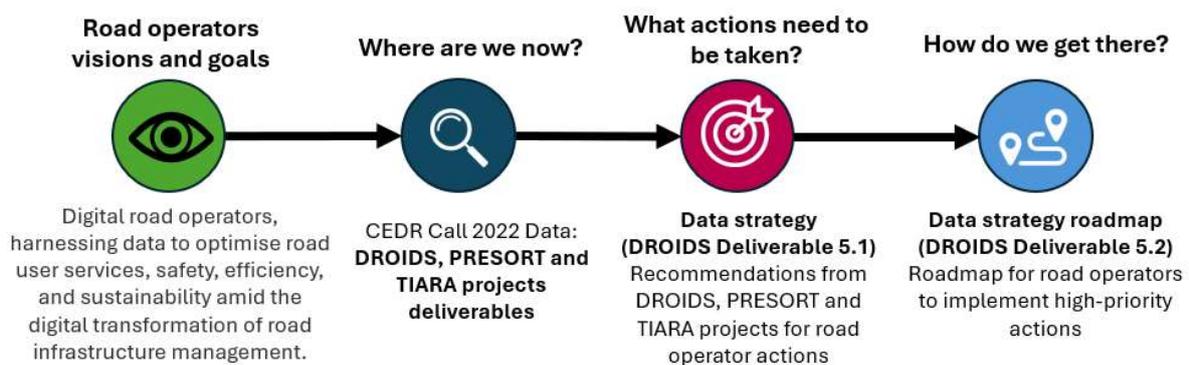


Figure 1 CEDR DROIDS project Data strategy and roadmap deliverables overview and content.

This data strategy, a roadmap for the digital road operator, is the final deliverable from the CEDR DROIDS project, aiming to provide both road operators and CEDR with guidance on their journey to become digital road operators. The roadmap outlines a set of actions to enable data as an asset across various areas of road operations, aligning with the European Data Strategy.

The background of the CEDR-funded DROIDS project research was the ongoing transformation of the road operators, including National Road Authorities (NRAs) and road managers, to digital road operators responsible for operating both the physical and digital road

infrastructure.

CEDR undertook and funded in CEDR 2022 Research call on Data three projects to research how road operators can maintain and share the digital road infrastructure data and improve the use of third-party data. The three project topics are listed below and illustrated in Figure 1.

- a) Maintaining and sharing the digital road infrastructure (DROIDS project)
- b) Improving the use of third-party data by NRAs (PRESORT project)
- c) Integrity, Authenticity and Non-Repudiation (e.g. proof of the origin, authenticity and integrity of data) integrated in Trust Models for C-ITS applications (TIARA project)

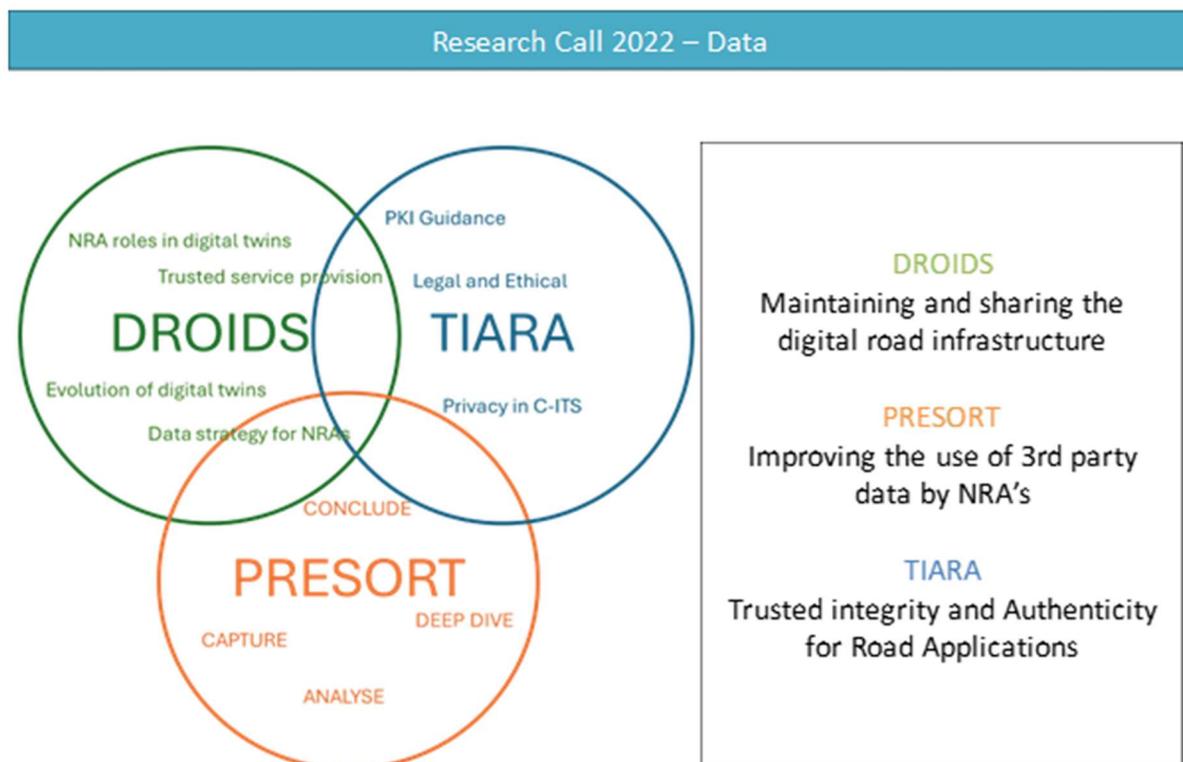


Figure 2: High-level topics researched across the three CEDR research projects

The three projects of the CEDR Call 2022 Data program, related to digital road infrastructure (DROIDS), third-party data (PRESORT), and trustworthy and secure data infrastructure (TIARA), provided insights into different perspectives, initiatives, and technologies driving the digital transition of road operations. The mentioned project recommendations were extracted and translated into actions in this roadmap, as presented in the figures below. Figure 3 provides an overview of the CEDR Call 2022 Data and the projects that follow this roadmap; Figure 4 illustrates the linkages between the scope of the three CEDR research projects.

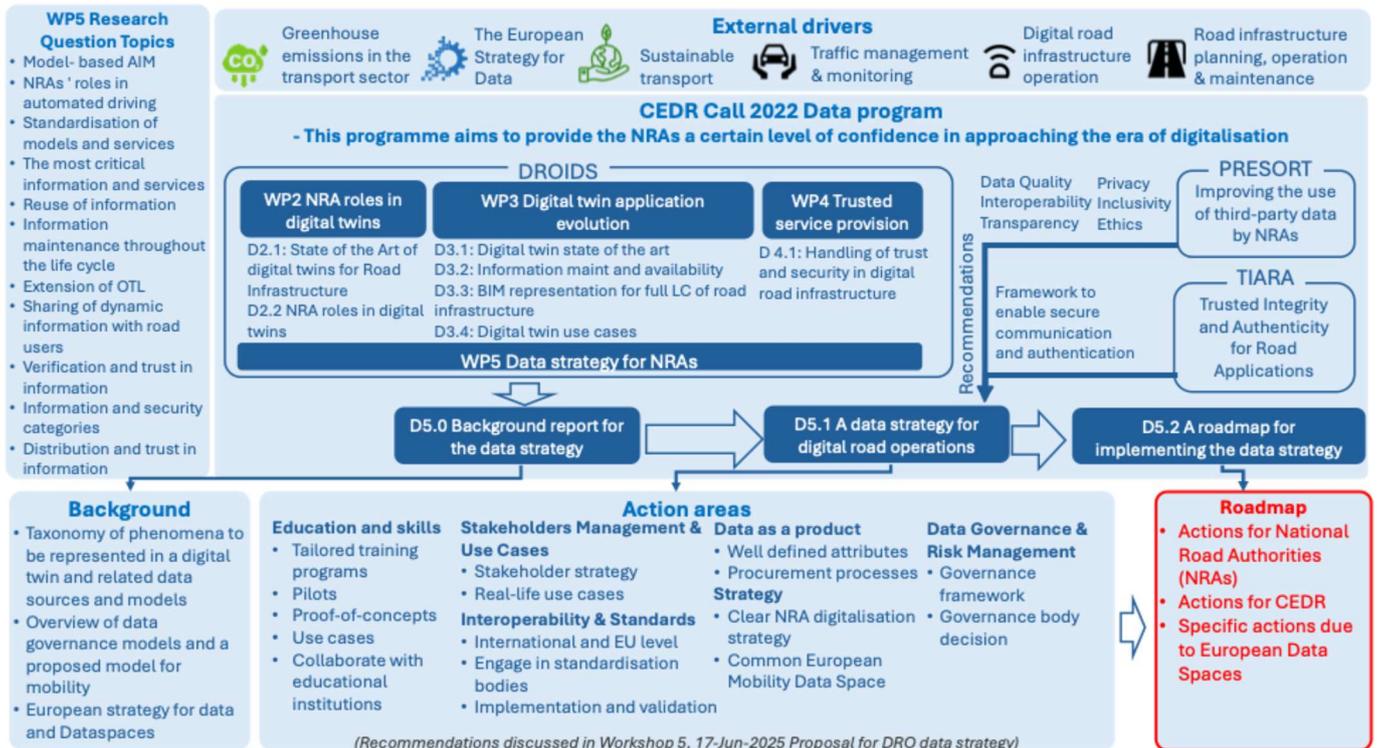


Figure 3: An overview of the CEDR Call 2022 Data Program projects, activities and deliverables

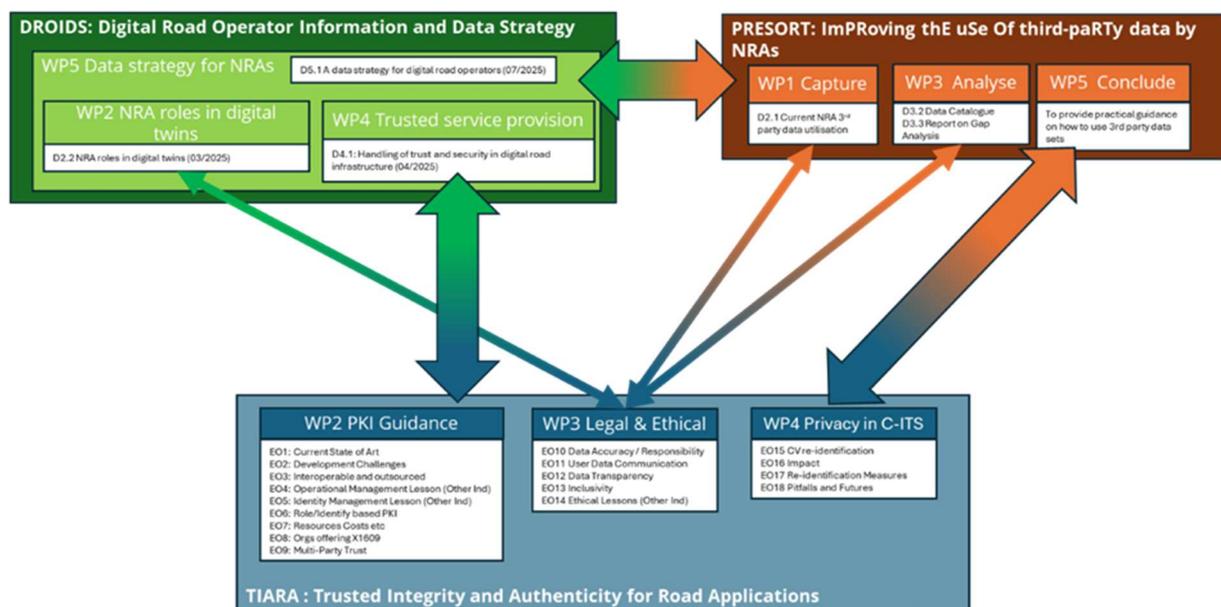


Figure 4 Linkages between the scope of the three CEDR research projects.

This study's results include the following chapters. *First*, in chapter 2 Methodology and methods used when building the data strategy and roadmap are presented. *Secondly*, in chapter 3 Action plan presents actions for the road operators and CEDR as well as specific actions for the European Data Spaces. Also, validity of the results is evaluated. *Thirdly*, in chapter 4 Conclusions the main conclusions of the study are presented.

1.2 Scope of the research

The **Scope of this research deliverable** is to conclude the DROIDS project results and data strategy into a roadmap for road operators. Therefore, this study effectively summarises the project's previous research questions and results, as well as the aforementioned CEDR Call 2022 Data projects PRESORT and TIARA results, as presented in the table below.

Table 1 DROIDS project Work Package 5 and the scope of its deliverables, including this data strategy roadmap deliverable 5.2.

DROIDS WP5 Data strategy deliverable (D)	Description of deliverable content	Expected end result
D5.0 Background report for data strategy (07/2025)	Presents key findings from the research results of digital blueprint, data governance models and data sovereignty.	A background study for the data strategy.
D5.1 A data strategy for digital road operators (07/2025)	Respond and refer to previous results on all research questions on the strategic level in form of a digital road operator data strategy by utilising the results from DROIDS project work packages and CEDR Call 2022 Data PRESORT and TIARA projects.	ER2 An overarching European data strategy for the role of physical and digital road operator
D5.2 A proposed roadmap for implementing the data strategy (this deliverable)	Proposed roadmap for the road operators to implement the data strategy.	Proposed roadmap for implementing the data strategy.

1.3 Terminology

The term “road operator” is used in this deliverable 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 term “road operator” therefore also covers road authorities that are public authorities responsible for similar tasks. The term has been adapted here 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's national authority responsible for the tasks above; in this study, the term 'road operator' is also used to encompass NRAs. Also, the term 'road manager' has been used by CEDR, which is here covered with the term 'road operator'.

Digital twins will support national road authorities and other road operators' tasks by (Kulmala, 2021)

- enhancing the effectiveness of planners, builders, users, and maintainers in all parts of the lifecycle of road network infrastructure and operations,
- providing a reliable digital copy of the state and properties of the road infrastructure throughout its lifespan,
- facilitating the real-time situational picture and reporting of the infrastructure level of service, condition, and use,
- enabling well-timed and informed maintenance of the infrastructure,
- facilitating the prediction of incidents and disturbances on the road network, and the preparedness of the road operator,
- improving risk management, and
- improving the level of service offered to road users

The term “Data governance model” refers to a cross-functional framework for managing data as a strategic enterprise asset. In doing so, data governance specifies decision rights and accountabilities for an organisation’s exercise of authority and control over decisions about its data (Abraham et al., 2019). Furthermore, data governance formalises data policies, standards, and procedures and monitors compliance.

The term “Phenomenon” refers to an observable event or condition in different parts of the road transport system that we can use our scientific knowledge to explain or predict. A model can represent the phenomenon in the context of a digital twin.

The term “Rulebook” refers to the internal rules that govern the data space. A Data Space Governance Framework is needed to define and manage these rules. The outcomes are collected in a ‘rulebook’ for each data space. Each participant should adhere to the rules in their data space’s rulebook.

The Term “Vocabulary services” refers to an overview of available data models in the data space. This enables participants in the data space to select common data models for a specific application. In the rulebook, some data models can be made mandatory to ensure semantic interoperability between participants. Vocabulary Services can also link these data models to APIs/technical interfaces for data exchange, providing semantics and syntax.

2 Methodology and research approach

2.1 DROIDS project methodology

The DROIDS project utilises the Digital Transformation Framework (DTF) structured approach, which supports the design, development, planning, and management of necessary organisational transitions. The DTF adopted for the DROIDS project is illustrated in Figure 5. Within the DTF, it is important to ensure vertical and horizontal alignment between the different columns and layers.

Vertical Alignment: This refers to the strategic alignment between requirements, gaps, and actions to fill these gaps, which form the three phases of the project. It follows a top-to-bottom approach, translating overall goals into relevant business cases and roadmaps. The information gained in one layer supports content creation in the layer below, ensuring a consistent approach to achieving the business cases, overarching strategy, and implementation roadmap.

Horizontal Alignment: This ensures completeness by not focusing only on technology or stakeholders but also considering other important organisational factors. It ensures alignment between stakeholders, core business, internal processes, and IT for an organisation. This alignment produces the expected outputs holistically and is considered in the individual work packages. It pays special attention to alignment with key stakeholders.

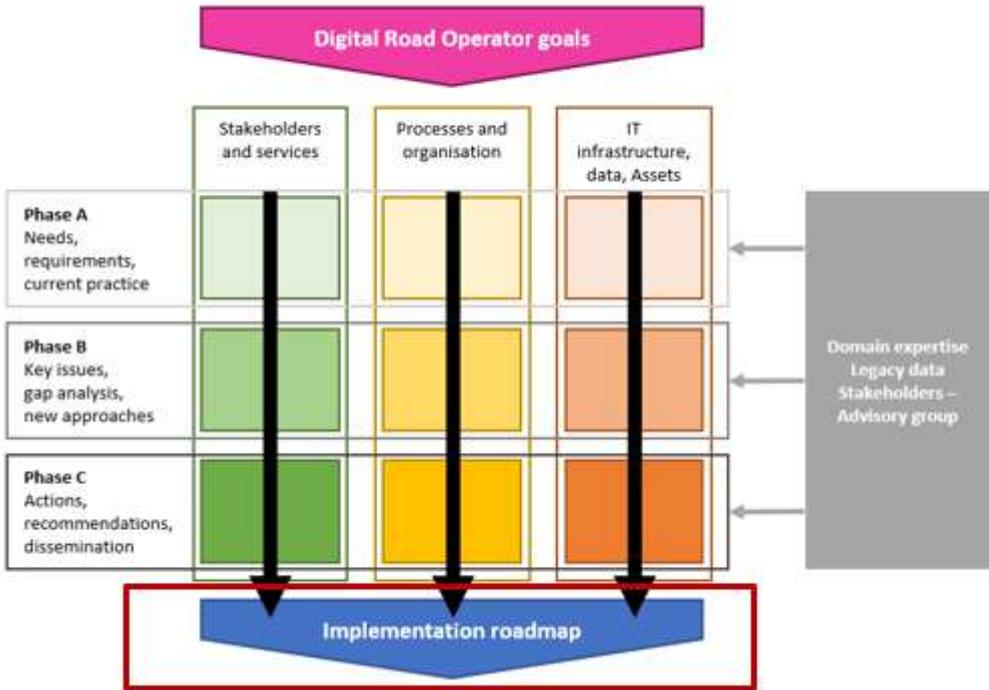


Figure 5 DROIDS project's Framework

2.2 Methodology of data strategy roadmap

The data strategy roadmap methodology is the final phase C in the previous chapter, where the DROIDS methodology is presented. This includes actions, recommendations, and the dissemination of results to stakeholders, as well as services, processes, organisations, IT, infrastructure, data, and assets.

The data strategy task started by preparing the basic structure of the strategy. This was then provided to the Conference of European Directors of Roads (CEDR), i.e., road operators mainly from the Project Executive Board (PEB), for their comments, and subsequently reworked until a feasible structure was agreed upon.

The Introduction chapter presented the CEDR Call 2022 Data digital road infrastructure DROIDS project in relation to other projects from the call, including PRESORT on third-party data and TIARA on trustworthy and secure data infrastructure. The data strategy roadmap builds on the results of the three mentioned projects.

The three above-mentioned CEDR projects resulted in recommendations for the road operators, which were extracted in the DROIDS deliverable 5.1, then organised according to the data spaces background study (D5.0) and support centre (DSSC.eu) building blocks and finally analysed and presented in this deliverable 5.2, where a roadmap of actions for the road operators. This process is described in the figure below.

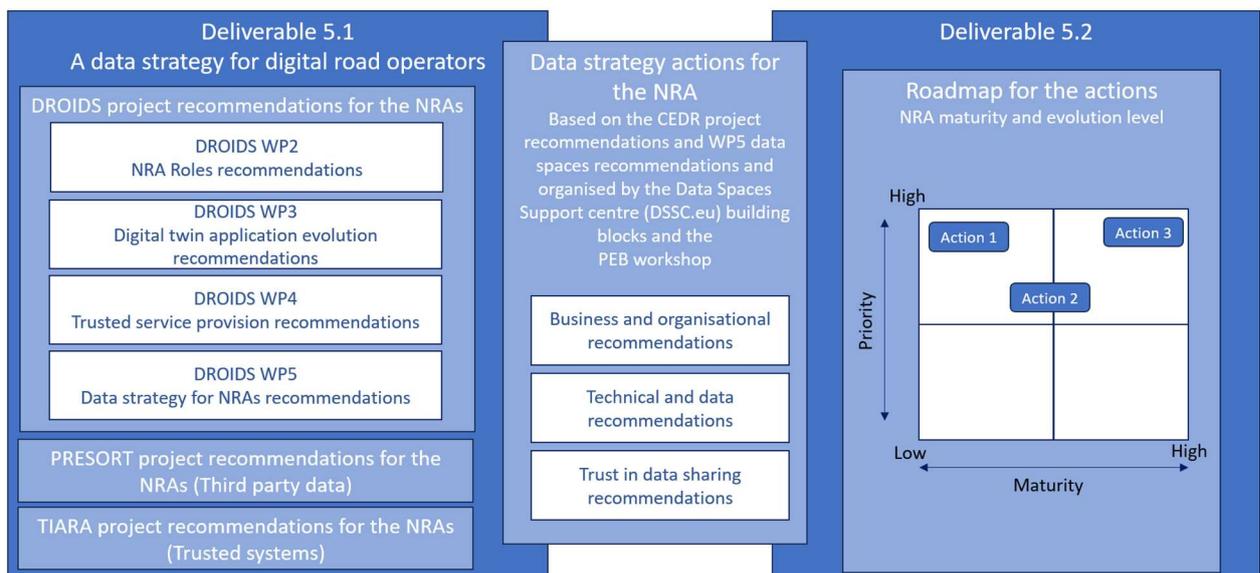


Figure 6 Recommendations from WP2-WP5 for implementing the data strategy

The following list includes the main deliverables from the three CEDR Call 2022 Data projects, which served as the primary input for the data strategy recommendations, subsequently transformed into actions for digital road operators. The deliverables are further introduced in the DROIDS deliverable 5.1 A data strategy for digital road operator (Bokolo et al 2025). Reference and origin to each of the actions (recommendations) presented in this deliverable are also included in the Appendix of this study.

DROIDS project on digital road infrastructure:

- D2.2 NRA roles in digital twins (Kulmala et al., 2025)
- D3.2 Information maintenance and availability (Soni, S., 2024)
- D3.3 BIM representation for full life cycle of road infrastructure (Soni, S., 2024)
- D3.4 Digital twin use cases – Digital transport regulations, opening new roads, automated lane level navigation (Soni et al., 2025)
- D4.1 Handling of trust and security in digital road infrastructure (Author, forthcoming)
- D5.1 A data strategy for digital road operator (Bokolo et al 2025).

PRESORT on third-party data:

- Deliverable 2 (D2): Improving the use of third-party data by NRAs – Baseline report (Stephenson & Spillard 2024)
- Deliverable 3.3 (D3.3): Report on Gap Analysis. (Soni & Oskina 2024)
- Deliverable 4.1 (D4.1): Report on Deep Dive (Huisken & Zhang 2024)
- Deliverables 5 (D5): Improving the use of third-party data by NRAs. Report on WP5 Conclude. Guidelines final report with
 - Deliverable 5.1. Use case identification and validation framework,
 - Deliverable 5.2. Data Acquisition and Quality Assurance Guidelines
 - Deliverable 5.3. Best Practices. (Laine et al. 2025)

TIARA on trustworthy and secure data infrastructure:

- Deliverable 2.1 (D2.1): Operation of Public Key Infrastructures: State-of-the-art and best practices (Wille, Skytterholm & Meland 2025)
- Deliverable 2.2 (D2.2): Guidance on the implementation of the C-ITS PKI. (Wille, Skytterholm & Meland 2025)
- Deliverable 6 (D6): National Road Authority guidance on legal and ethical use of data (Kotilainen & Kulmala 2025)
- Deliverable 8 (D8): Connected vehicle deanonymisation research review and impact study. (Maerivoet & Ons 2025)

2.3 Methods used to implement the data strategy roadmap

This chapter outlines the methods employed in implementing the roadmap for the digital road operator data strategy. This chapter does not cover the methods used in the previous DROIDS research and deliverables, which are, however, briefly mentioned in the chapters and explained in more detail in the DROIDS deliverables referred to in this study.

Methods used when implementing the roadmap for the digital road operator data strategy included literature review, collaboration with road operators and private industry experts, as well as a workshop. The methods are presented in more detail in the following paragraphs.

The methods and processes of identifying the roadmap actions are illustrated in the figure below. Delivery 5.1 contains the complete overview of all the recommendations that have been derived from the three CEDR projects on digital road infrastructure (DROIDS), third-party data

(PRESORT) as well as trustworthy and secure data infrastructure (TIARA).

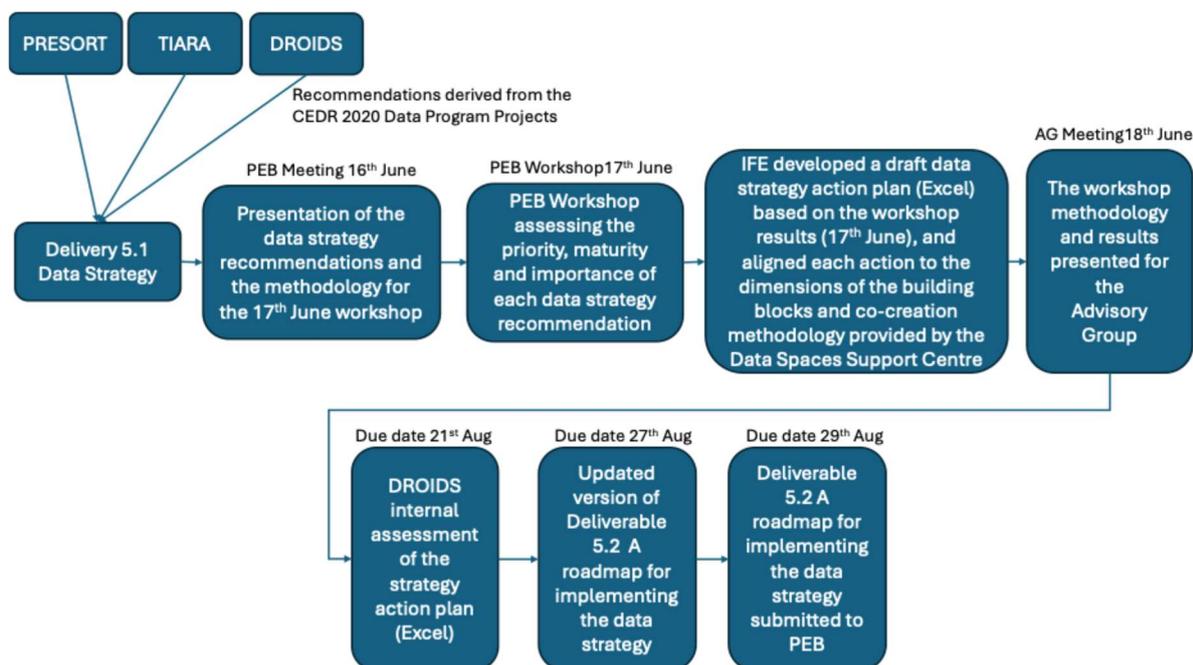


Figure 7: The process of establishing the actions

Literature was primarily used to draw recommendations from the CEDR Call 2022 Data projects, including the results of the DROIDS, PRESORT, and TIARA projects, for the implementation of the data strategy and roadmap.

Collaboration with the three CEDR Call 2022 Data projects of DROIDS, PRESORT, and TIARA, as well as their work package (WP) leaders and experts, was conducted to ensure feedback on the roadmap implementation. Collaboration with experts was facilitated through project meetings and by sending emails with questions to gather results and feedback on the roadmap implementation. Recommendations for road operators from the three CEDR projects were presented at the CEDR PEB meeting on June 16, along with the methodology for processing them at the workshop held the following day.

A workshop on digital road operator data strategy was conducted on June 17, 2025, as part of the CEDR Call 2022 Project Executive Board (PEB). The participants (n = 33) in the PEB meeting included road operators, as well as experts from the DROIDS, PRESORT, and TIARA projects—the workshop aimed to gather input from road operators regarding the data strategy and roadmap implementation.

The workshop was conducted in a TEAMS virtual meeting. The participants shared a collaborative and interactive board, where they could comment on the data strategy and roadmap recommendations and actions.

The actions had been evaluated beforehand in three categories:

- Business and organisational: skills and capabilities, regulation, use cases
- Data and technical: data governance, data analysis and quality, interoperability, infrastructure and architecture
- Trust: data security, data protection and privacy, legal and regulation, ethical

Furthermore, the recommendations had been evaluated beforehand by two criteria: first, by their *priority* of recommendation, and secondly, the road operator’s *maturity* level in digitalising

road operations, as presented in the following figure.

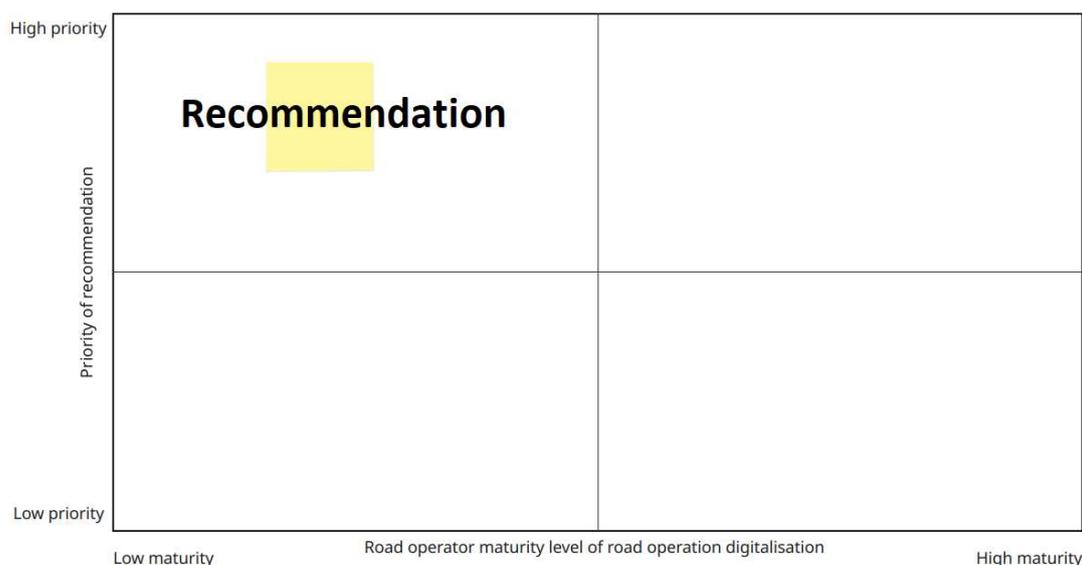


Figure 8 : Collaborative board used in the workshop to evaluate data strategy recommendations which then later transformed into actions for implementing the roadmap.

The following three tasks, along with their definitions, were given to the participants.

Task 1: Check the validity of the DROIDS, PRESORT and TIARA recommendations

- Do you find the recommended actions for road operator valid? Please comment in the sticky notes.
- Check, at a minimum, your project's recommendations. What elements or actions are missing?

Recommendations are considered strategic that can be applied to most of the road operators' use cases in digital road operation.

Task 2: Position the sticky note according to maturity and priority

- Please evaluate the strategic priority and maturity level of the recommendations in the elements below.

Maturity refers to the road operator's combined maturity of people, processes, organisation, and technology regarding the digitalisation of road operations.

Task 3: What are the most important priorities for road operator?

- Add (any) emoji to the sticky note by clicking the note and selecting emoji

Analysis of the workshop results was conducted by the DROIDS research team, whereas the work package leaders were responsible for reviewing the workshop input that included the recommendations (actions).

For the analysis, a spreadsheet was created with all the dimensions and information collected during the workshop introduced above. The DROIDS project team then conducted an internal mainly qualitative review of the recommended actions, focusing on their priority, maturity, importance, and dimensions. A quantitative evaluation was conducted by calculating the number of high-priority actions identified by the workshop participants. Actions related to each other were grouped.

When identifying the topics of each action group, the Data Spaces Support Centre (DSSC) Building Block Overview (2025) was used to help determine the topic and at the same time to align with the DSSC (Figure 9).

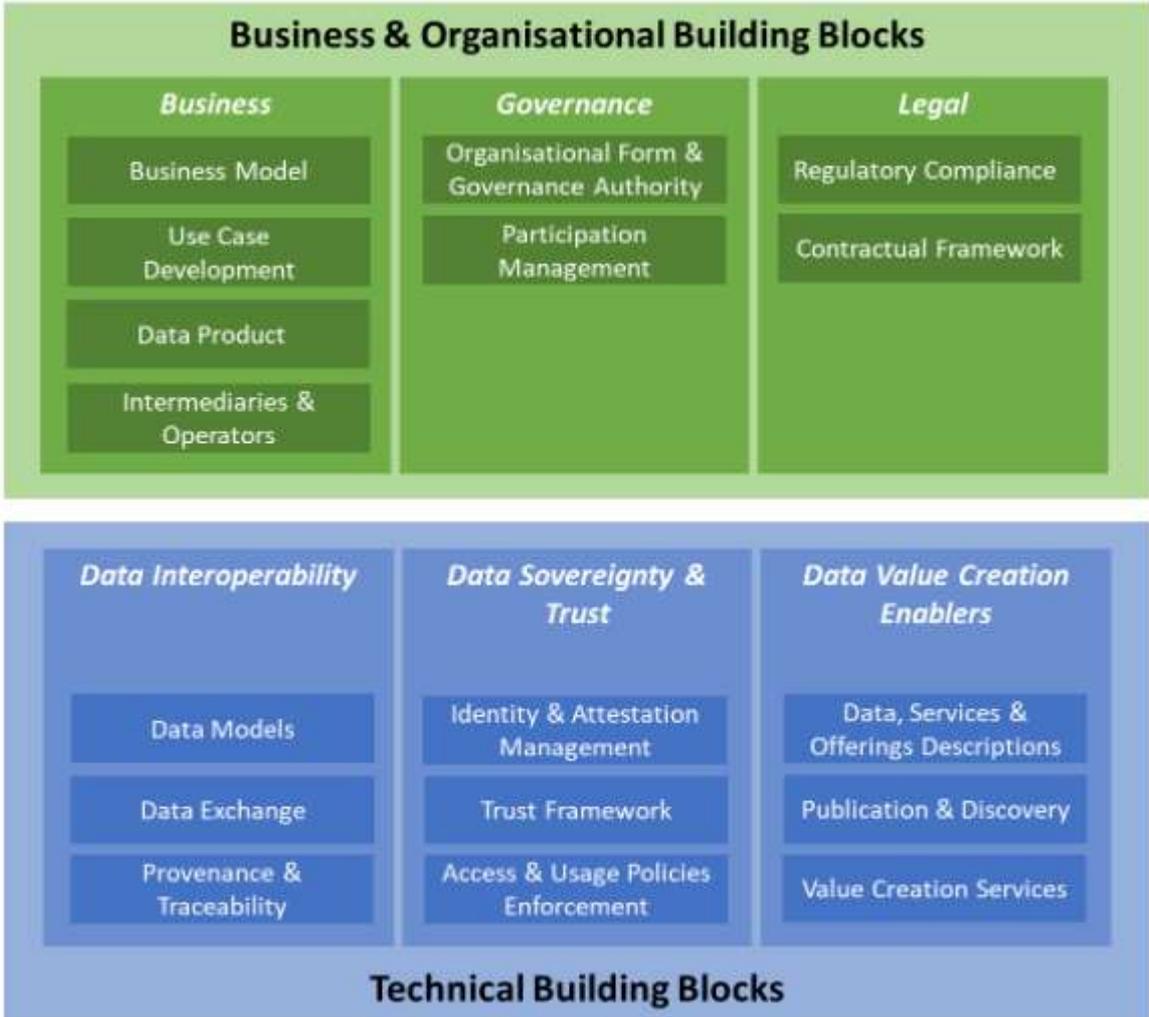


Figure 9 Data Spaces Support Centre (DSSC) Building Block Overview. (2025)

Validation of the proposed roadmap actions was evaluated by the DROIDS work package leaders, after which the results were sent to the road operator, CEDR PEB, for review and comments. The actions were also presented at the DROIDS Advisory Group, which included public, private and industry members, meeting on 2025 June 18. Based on the feedback, the actions were edited and finalised together with the roadmap.

3 Action plan

The data strategy action plan and roadmap for the digital road operator presented in this chapter has been divided into the following three groups of actions that are introduced here in subchapters:

- 1) Actions for the road operators
- 2) Actions for the Conference of European Directors of Roads (CEDR)
- 3) Specific actions for the European Data Spaces

The three mentioned subchapters concentrate on the **actions that have been evaluated as high priority** for the road operators. Additionally, a summary of medium-priority actions is provided.

The actions should also be reviewed, as they have been evaluated (see Appendix 5.1, 5.2, and 5.3) based on the digital road operation **maturity level of the digital road operator**. For the road operator to analyse its digital road operation maturity level, for example, the Digital Twin maturity levels and Technology Readiness Level scale introduced in the DROIDS deliverables 2.1/3.1 (Soni et al. 2025) could be used.

A more detailed list of actions, including references to the source studies and projects' results, is further introduced in the Appendix of this study. The Appendix lists and provides draft evaluation results for high, medium, and low priority actions. The Appendix also includes a grouping of the individual actions, along with their qualitative and quantitative analysis results, providing further details.

3.1 Actions for the road operators

This chapter describes recommended actions for the road operators. A road operator, whether a private entity or a public entity such as a National Road Authority (NRA), is a body responsible for a Member State's Road network, which plans, constructs, and maintains national and county roads. For the full list of actions with draft evaluation results details, see Appendix 5.1, 5.2 and 5.3 of this study.

3.1.1 High-priority actions for road operators

The following seven high-priority action categories, which include ten actions (A1–A10), further described in the tables below, are recommended for inclusion in the roadmap for road operators to become digital road operators:

1. Provide education and enhance skills (Table 2)
2. Implement interoperability and utilise standards (Table 3)
3. Carry out stakeholder collaboration and prioritise use cases (Table 4)
4. Develop and purchase data and services based on standards, guidelines and design principles (Table 5)
5. Develop data governance and risk management framework (Table 6)
6. Implement a change management process (Table 7)
7. Implement a trust framework (Table 8)

Table 2 Action 1: Provide education and enhance skills

Action ID	1. Provide education and enhance skills
A1	<p>A training programme tailored to different road operators and contractors for a particular country based on their digital readiness levels and high priority use cases should be developed. Besides traditional competence development, the programme should include more practical approaches, such as participating in pilots, smaller proof-of-concept activities, or use-case-driven training. The educational institutions should be involved in the training program. For example, the following curriculum could be established:</p> <p>(1) Procurement of digital tools, services and third-party data, including competitive dialogue and innovation partnerships. (Laine et al., 2025), (2) IoT, (3) Digital Twins, (4) HD Maps, (5) Digital trust (PKI) and security (6) C-ITS services, use cases and their limitations (7) BIM, (8) AIM, (9) Interoperability and standards, (10) Cyber security, (11) Data governance, (12) Data science, (13) WEB3 and (14) Data space technology</p>

Table 3 Action 2: Implement interoperability and utilise standards

Action ID	2. Implement interoperability and utilise standards
A2	<p>Utilisation of international and EU standards shall be prioritised, but where they do not exist, national standards should be used. Appointed ambassadors from the road operation domain should take part in different standardisation committees and forums. Standards and their implementation profiles need to be validated and implemented, e.g. C-ITS in C-Roads Platform. High-priority standards within the following areas should be prioritised:</p> <ul style="list-style-type: none"> • Cooperative Intelligent Transport Systems (C-ITS PKI, C-Roads) • Real-time Traffic Information (RTTI delegated regulation, Datex II) • Road Infrastructure Data (OTL) • Privacy (GDPR, ePrivacy, ITS) • Road Infrastructure Asset Management (BIM, AIM, GIS).

Table 4 Actions 3 and 4: Carry out stakeholder collaboration and prioritise use cases

Action ID	3. Carry out stakeholder collaboration and prioritise use cases
A3	<p>By engaging stakeholders, road operators can ensure that data initiatives are closely aligned with the digital needs of road operations. This includes:</p> <ul style="list-style-type: none"> • Deploy the most important and useful digital representation use cases about road operators' core business in a cost-effective manner <p>The national road operators should outline real-world challenges and opportunities in prioritised use cases that promote the acquisition of new data sources. This can be achieved through early engagement with end-users by demonstrating selected use cases, pilots, and proof-of-concept activities.</p>
A4	<p>The road operators should develop a stakeholder strategy to engage with key data providers (e.g., road authorities, third-party data providers, citizens) to establish a shared vision on utilising data as an asset, ensuring comprehensive data coverage and fostering innovation (the CEDR PRESORT project, e.g. Laine et al. 2025). The national road operators should encourage collaboration between public administrations and private companies to share costs and expertise.</p>

Table 5 Actions 5, 6 and 7: Develop and purchase data and services based on standards, guidelines and design principles

Action ID	4. Develop and purchase data and services based on standards, guidelines and design principles
A5	<p>Data has become a new raw material for service provisioning and innovation in digital road operations (e.g., Digital Twins, AI tools, HD Maps). New, digital services and products should be developed, supporting data as an asset, by carefully considering the following:</p> <ul style="list-style-type: none"> • Development of new digital services and products based on data, adhering to a set of recommendations for interoperability and standards (such as data formats and quality attributes), ownership and usage rights, laws, and regulations (GDPR, Data Act, Data Governance Act). • Focus on developing mature, well-functioning products that have undergone MVP verification, provide clear commercialisation opportunities • Leverage open data sources while safeguarding sustainability, quality and accuracy.
A6	<p>A revised set of guidelines for purchasing data products and services must be incorporated into public procurement procedures (and supported by digital contract negotiations in data spaces). (e.g. Laine et al. 2025)</p>
A7	<p>Development and innovation of new services and products should integrate human-centric design principles and co-creation with relevant stakeholders.</p>

Table 6 Action 8: Develop a data governance and risk management framework

Action ID	5. Develop data governance and risk management framework
A8	<p>The national road operators should agree on a data governance framework that:</p> <ul style="list-style-type: none"> • Define the data attributes that are align with the requirements early (e.g. accuracy, coverage) • Ensures the efficient and effective utilisation of information, including backwards compatibility and diversity • Covering areas such as data privacy, data security, data quality, data catalogues and metadata management, data in cloud and hybrid environments, data ethics, data governance tools, and data governance maturity. • Supports quality metrics with well-established and accepted measurement methods • Road operators should be mindful of potential data quality issues in less populated regions, where third-party data providers often operate. • The road operator should embed legal, contractual and ethical responsibilities for data accuracy in their operation • Aims to integrate data from various sources and systems to meet objectives (accuracy, consistency, coverage, other requirements), facilitating interoperability and ensuring that data across the stakeholders is compatible and usable. • Effectively managing compliance and mitigating risks in data handling (e.g., sensitivity, potential impact, and C-ITS services) requires a strategic approach, and data governance plays a pivotal role. • Work across sectors to align legal frameworks, technical standards, and operational practices. • Conduct regular security audits • Define clear consent models, especially for pseudonymised vs. personal data that communicates well with the consenter. • Integrate privacy-by-design into procurement rules and certification processes • Work with legal, procurement and audit to elevate data as a deliverable and communicate all data policies internally and externally • Introduce adaptive governance, allowing stakeholder-led audits

Table 7 Action 9: Implement a change management process

Action ID	6. Implement a change management process
A9	Implement a change management process that supports new processes, organisational changes or adoption of technologies to ensure smooth transition and acceptance.

Table 8 Action 10: Implement a trust framework

Action ID	7. Implement a trust framework
A10	Apply adequate monitoring of PKI infrastructure to detect technical and security issues. Using the EU C-ITS PKI will allow for effective data exchange across borders

3.1.2 Medium priority actions for road operators

Medium-priority actions for road operators included topics such as risk management, standards, education and skills, digital product management, a use-case-driven approach, data governance, stakeholder management, architecture, and requirements. These medium-priority topic actions are shortly described in the next paragraphs.

The risk management topic included the use of risk-tiered regulation, based on the sensitivity and potential impact of the data, and to carry out risk evaluation when communicating and developing ITS/C-ITS services.

Standards topic included medium priority actions of following: Harmonise privacy standards across borders (GDPR, ePrivacy, ITS); Engage in standardization initiatives; Adopting BIM, OTL and open data standards; Make use of C-Roads (for definitions and standards); Develop OTL to improve the quality, consistency, and machine readability of the data; Adhere to the EU standard for C-ITS PKI; Transparency of Data Collection and Processing; For national implementation of the RTTI delegated act (EU 2022/670) – create and agree on national standard DATEXII profiles for all datasets early in the process to ensure data interoperability across all municipalities and other players and creation of wider databases (use of DATEXII Recommended Reference Profiles as a base).

Education and skills topic included medium priority actions of following: Understand and acquire expertise on C-ITS services, use cases and their limitations; For low maturity digital road operation: educate / invest in – Digital Transformation (separate to IT Department); The PKI system is complex, and it is recommended that the road operator undertake a concept stage analysis using a rigorous development methodology to establish requirements, architecture and verification & validation activities; Hire skilled resources.

Digital products management topic included medium priority actions of following: Public procurement process: guidelines and decision-support on 3rd party data acquisition process (Laine et al., 2025); Phased Implementation; Strategically Integrate AI and Sensor.

Use case driven approach topic included a medium priority action to third party data that may

have many use cases for the organisations to share costs.

Data governance topic included medium priority action of following: SLA monitoring: third-party data providers meet the expected standards for data delivery and quality; Periodic Data Quality Assessments; road operator's decision to define rulebook (governance model) for the data space; road operator's Select Data Space Service offering/ Data App; System Auditing; Conduct regular audits; Data Redundancy and Cross-Verification; Independent Certification; Pilot the usefulness of BIM and AIM information within HD maps in cooperation with HD map providers. at a minimum ensure that the information related to assets such as GIS information is organised, updated, and complete.

Stakeholder management topic included medium priority actions of following: Follow inclusive and transparent communication recommendations; Engage in concrete cross-border collaboration (e.g. Nordic countries) activities regarding data procurement (wider scale adds innovation incentives) and data analytics (no need to re-invent the wheel); Foster collaboration among stakeholders, develop innovative policies, and address legal and institutional barriers through strategic planning; Encourage collaboration between public administrations and private companies to share costs and expertise; Good collaboration between different C-ITS service providers; Enhance supplier collaboration, utilize technology and automation; Establish / participate in interest groups for C-ITS service providers.

Architecture topic included medium priority actions of following: Adopt scalable and flexible infrastructure solutions, embrace emerging technologies, and prioritize modular architecture; Make key decisions on cloud vs on prem, Data Lake vs Data warehouse etc. and prioritize integration processes and authoritative data (reduce duplication). Data collection plan on harvesting data from various applications, systems, service providers etc.; Leverage managed PKI services to outsource PKI management, reducing the burden on internal teams and ensuring access to experts; Catalogue all NRA Data Assets, make available to staff and selected partners. Provide a data dictionary +documentation to authorised data consumers. Categorise regarding level of confidentiality; Data Authentication; Extend scope beyond C-ITS to apps, infotainment, and navigation platforms (connected services).

Requirements topic included a medium priority action of road operator to define technical and organisational requirements.

3.2 Actions for CEDR

Road operators carry out their missions on road network operation and other responsibilities based on national legislation and policy priorities. The Conference of European Directors of Roads (CEDR) on the other hand will a) share information and best practices among road operators, b) carry out R&I activities and producing guidelines addressing common topics of interest for the road operators, and c) act as the mouthpiece of the road operators towards the European Commission and other stakeholder groups when safeguarding the core business and strategies of the road operators in European regulation, innovation, and deployment.

3.2.1 High priority actions for CEDR

The key priority action for CEDR is **to establish appropriate CEDR activities that support the evolution of road operators towards digital road operation**. Such an activity can be a temporary working group, a workshop or series of them, or a research call, for instance. The actual format of the activity needs to consider the work topic, the needs of the road operators, and the urgency of the need for the activity. Following action category with a list of possible action topics is presented in the Table 9 below.

Table 9 Action 11: Establish appropriate CEDR actions to support digital road operation

Action ID	8. Establish appropriate CEDR actions to support digital road operation
A11	<p>Establish appropriate CEDR activities that support the evolution of road operators towards digital road operation. According to the road operators participating in the DROIDS workshops, the current list of possible topics for such a CEDR activity is:</p> <ul style="list-style-type: none"> • Establishment of skills needed by road operators and their contractors in digital representations (models, shadows, twins) and related processes including cybersecurity. • Identification of the most important digital representation use cases and their types based on European, national and CEDR priorities as well as a socio-economic assessment of the different use cases in various deployment scenarios • Aim to ensure that road operators embed legal, contractual and ethical responsibilities for data accuracy or in general high data quality in their operation so that the society and key stakeholders can trust and thereby fully utilise the data from the road operators. • Use of open standards to reduce dependency on proprietary technologies and patents, ensure cross-member state harmonisation, improve data quality and transparency as well as preserve privacy. • Define the role and actions of the road operators in joining the European mobility data space promoted by the European Commission including the need of a European data governance body. • Development of a clear digitalisation strategy for road operators taking on board related European strategies, national priorities and the varying digital maturity of the road operators.

3.2.2 Medium priority actions for CEDR

The primary medium priority action for CEDR is to **monitor the developments in road infrastructure and transport system-related technology evolution, digitalisation, automation, data, and regulation**. This should be a continuous activity to ensure that CEDR can react quickly to matters affecting the core business of road operators and requiring urgent attention.

3.3 Specific actions for the European Data Spaces

The data space actions are secondary to the actions supporting digital road operations. Still, they are required to support the use of data in a more complex digital ecosystem for future road operations, which will require data from various sources and stakeholders while maintaining privacy, commercial interests and trust. Figure 10 illustrates the primary assets provided by the Data Spaces Support Centre (DSSC)(Data Spaces Support Centre, n.d.) to facilitate data spaces.

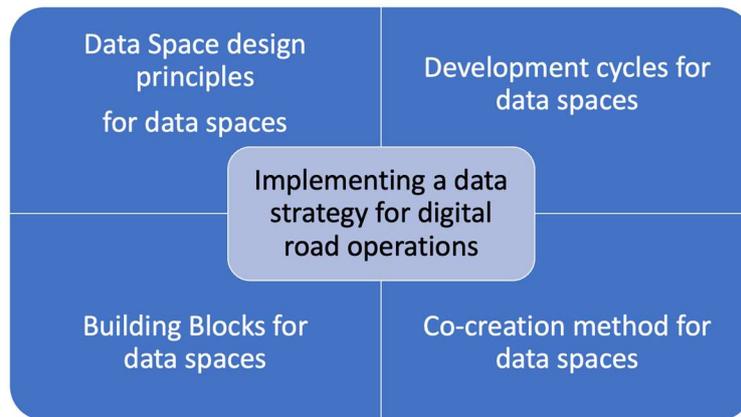


Figure 10: Implementation Roadmap Enablers

The specific actions for the European Data Spaces have been grouped with the actions for the road operators and CEDR. The high-priority action categories and actions (A12–A15) outlined in the tables below align with the recommendations and guidelines from DSSC and indirectly support the European Data Strategy (European Commission, 2020):

- 12. Implement an EMDS-compliant data space supporting digital road operations (Table 10)
- 13. Formalise the standards to be applied for digital road operations (Table 11)
- 14. Implement a data governance framework and a data governance body (Table 12)

Table 10 Action 12: Implement an EMDS-compliant data space supporting digital road operations

Action ID	9. Implement an EMDS-compliant data space supporting digital road operations
A12	Road operator should create a data space that is compliant with the common European Mobility data space (European Commission, 2023). Deployment of data spaces supporting road operations should comply with the data spaces design principles (Appendix 6.4), the step-by-step approach in the Co-Creation Method (Appendix 6.5) and the Deployment stages (Appendix 6.6) provided by DSSC to engage stakeholders in the following key areas: (1) Developing use cases and identifying functional requirements, (2) Defining the governance structure (Technical and organisational), (3) Developing data products and services, and (4) Defining the architecture and the technical infrastructure.

Table 11 Action 13: Formalise the standards to be applied for digital road operations

Action ID	10. Formalise the standards to be applied for digital road operations
A13	The standards agreed on for digital road operations should be implemented as a data space "vocabulary service" (see chapter 1.3 Terminology) that acts as a central repository for standardised data models and their documentation, enabling semantic interoperability.

Table 12 Actions 14 and 15: Implement data governance framework and data governance body

Action ID	11. Implement data governance framework and data governance body
A14	The data governance framework agreed by the road operators should be implemented according to the recommendations proposed for the Common European Mobility Data Space (Scholliers et al., 2025). Road operators should agree on a rulebook (governance model) for the data space.
A15	CEDR should agree up on the form for the data governance body (e.g. EU wide, Member state, Expert group) for digital road operations by reviewing the analysis performed by Directorate-General for Mobility and Transport (Scholliers et al., 2025)

3.4 Validity of the results

This chapter evaluates validity of the data strategy roadmap and its results of recommended actions for road operators, CEDR and specific actions regarding the European Data Spaces. The validity evaluation, methodology, and methods used in the study are described in Chapter 2, Methodology and Research Approach. The table below presents the results of the validity evaluation.

Table 13 : Validity of the data strategy roadmap and its actions result.

Validity Item	Context description	Validity impact risk assessment	Validity risk level	Mitigating action
Road operator feedback	Road operator feedback was limited on deliverable reviews	The risk of limited number of actions with value to the road operator.	Medium	Questionnaire and interview feedback was well received. Workshop collaboration.
Variations in digital maturity in the different EU Member States	Only a limited number of Member States have participated in the DROIDS activities.	The anchor a cross-EU data strategy, the digital maturity level will impact Member state specific actions.	High	Perform a digital maturity assessment in each Member State.
Technical and business areas outside of CEDR Call 2022 Data research topics	The CEDR Call 2022 Data call covered wide range of topics, but coverage can be limited.	Actions leave out some business and technical areas that could be critical to the stakeholders.	Medium	Wide range of methods used: collaboration with CEDR, PRESORT and TIARA projects, workshops, interviews and questionnaires.
Mobility data governance survey	Due to the limited feedback on the questionnaire on data governance, the concept of a data governance framework and the related terms and processes may be	A data governance framework is key when implementing a data sharing approach like the Common European Data Spaces, with multiple stakeholders across the Member	Medium	Skills and training program on data governance

	unfamiliar.	States		
The data space landscape	The data space landscape evolves continuously and it's out of scope for the project to have completed overview of the latest advancements and reports.	It may be that there are relevant contributions from other data space domains like the green deal data space, energy data space or smart city data space, that could have contributed to the recommendations.	Medium	Engage in the Data Spaces Support Centre activities
Data space competency	When presenting the concept of data spaces, many of the workshop participants had limited or no previous experience or knowledge.	Assessing the data spaces related actions could pose a challenge.	Medium	Skills and training on data spaces
Data sources documented in the digital blueprint (Excel spreadsheet) are not complete	The identification of data sources was limited to the literature review, experts participating in workshops and the reviews of documents.	The overview of the data sources was relevant for the discussions about the role of the Common European Data Spaces as part of the data strategy, but due to the scope of DROIDS a complete mapping for each Member State was not possible.	Low	Relevant stakeholders for each member state, including Road operators, must be identified and participate in the identification of relevant data sources. The proposed co-creation methodology from Data Spaces Support Centre supports the mobilisation of the relevant stakeholders at the right time.

4 Conclusions

This CEDR-funded Digital Road Operator Information and Data Strategy (DROIDS) project deliverable presents the final results of the project. The study compiles findings from all the previous work packages (WPs) related to road operator roles, digital twin evolution, trusted service provision, and data strategy. Additionally, the results from other CEDR Call 2022 Data projects, which responded to third-party data (PRESORT) and a trustworthy, secure data infrastructure (TIARA), were also included. In the CEDR and aforementioned projects' collaboration, a conceptual data strategy and roadmap were developed, acknowledging the different road operators at varying maturity levels.

The roadmap action implementation schedule differs between road operators, as it is dependent on two factors: first, the road operator's *maturity* level (or technical readiness level) in road operation digitalisation, and secondly, the *priority* of the action for the local road operator. Also, implementation of actions depends on combination of the local road operator ambitions and budget constraints.

The data strategy roadmap results include 11 action categories, which further comprise 15 actions for the digital road operators. The following paragraphs summarise the action categories and actions included for road operators, CEDR, and specific actions concerning the European Data Spaces.

The following **seven high-priority action categories for road operators** were proposed in the roadmap:

1. **Provide education and enhance skills.** Tailored training programs and practical competency development using pilots, proof of concept and real-life use cases. Also, collaboration with educational institutions.
2. **Implement interoperability and utilise standards.** Actively involved in the implementation of International and EU standards to achieve interoperability.
3. **Carry out stakeholder collaboration and prioritise use cases.** Develop a stakeholder strategy with a use-case-driven stakeholder engagement plan.
4. **Develop and purchase data and services in accordance with established standards, guidelines, and design principles.** Treat data as a raw material with well-defined attributes and procurement processes. Use human-centric design principles and co-creation.
5. **Develop a data governance and risk management framework.** Agree on a data governance framework that safeguards, among other things, data quality, compliance, privacy, security, data diversity, stakeholder-led audits and ethics.
6. **Implement a change management process.** Implement a change management process that supports new processes, organisational changes, or the adoption of technologies to ensure a smooth transition and acceptance.
7. **Implement a trust framework.** Monitor PKI infrastructure to detect technical and security issues. Use the EU C-ITS PKI to allow for effective C-ITS data exchange across borders.

The following **high-priority action category for the Conference of European Directors of Roads (CEDR)** was proposed in the roadmap:

8. **Establish appropriate CEDR actions to support digital road operation**, such as establishment of needed skills for road operators and contractors, identification of the most important digital representation use cases and their types, ensure road operators embed in addition to legal also contractual and ethical responsibilities for

data accuracy, use of open standards, definition of road operators role in the European mobility data space, development of digitalisation strategy.

The following **three high-priority action categories for specific actions for the European Data Spaces** were proposed in the roadmap:

9. **Implement an EMDS-compliant data space supporting digital road operations.** Follow the step-by-step approach in the Co-Creation Method provided by the DSSC and the Data Spaces Design Principles.
10. **Formalise the standards to be applied for digital road operations** as a data space "vocabulary service" that acts as a central repository for standardised data models and their documentation, enabling semantic interoperability.
11. **Implement data governance framework and data governance body.** Use recommendations proposed for the Common European Mobility Data Space, agree on a rulebook (governance model) for the data space and form for the data governance body for digital road operations.

Most of the actions were directed to the road operators. The actions directed to CEDR were fewer but still important, as several key actions and decisions by road operators require support from CEDR-initiated activities, including the sharing of best practices, identification of key digital representation use cases, and guidance to ensure trust in road operator data, among others.

The next step for the CEDR and Member States' road operators is to review the actions proposed in this data strategy roadmap for digital road operators. The review should start by identifying the priority goals and business objectives of the organisation. Next, the details of the actions should be aligned with the current digital road operation maturity level of the road operator.

In a future Mobility Data Space, Public Key Infrastructure (PKI) is crucial for establishing trust and ensuring data sovereignty. A holistic approach to trust should be applied in the aforementioned actions, which are already reflected in the areas of education and skills, interoperability and standards, and architecture.

The actual validity of our results is influenced by the extent of road operators' feedback throughout the DROIDS project lifecycle. As reported in this and other DROIDS project deliverables, feedback from road operators was received through questionnaires and interviews, albeit to a minor extent, as well as through deliverable reviews.

A limited number of road operators participated in the final workshop to review the data strategy, and where the roadmap actions were discussed. The digital road operation level of maturity among the participating road operators was estimated to be medium to high, which could have had an impact and potentially caused bias in the results. This is because road operators with different maturity levels could review the proposed roadmap actions from different perspectives.

Other limitations of the study include the continuous evolution of the data space landscape, the restricted data space competence knowledge among the road operator participants in the work, and limitations on documenting data sources. There were also many technical and business development areas related to digital road operation that the three CEDR projects of DROIDS, PRESORT and TIARA did not cover. Such areas included, for example, specific service-dependent digital infrastructure developments, Service Level Agreements (SLAs), and data analysis capabilities.

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6 Appendix

This Appendix presents draft evaluation results of the actions for road operators. To find more information about the evaluation and used methods, please see chapter Methodology in the study for more information.

These Appendix draft evaluation results, presented in the subchapter tables below, do not completely reflect the final results of the actions presented in this study as some of the actions were reviewed and adapted during the analysis.

The actions have been sorted according to their evaluated priority. Each action is provided with the following additional details:

- Topic: identified topic, which are partly extracted from the Data Spaces Support Centre Building Block Overview.
- Action based on the CEDR Call 2022 Data studies results recommendations.
- Source: reference to CEDR Call 2022 Data projects of DROIDS, PRESORT, TIARA and possible other sources.
- Maturity: estimated digital road operation maturity level of the road operator.
- Support: How many support votes did the action get.
- Comments: comments that were given by the DROIDS research team members for the action.

6.1 Actions for road operators

6.1.1 High priority

Topic	Action	Source (deliverable)	Maturity	Support	Comments
Education and skills	Invest in Staff Education	PRESORT (3.3)	Low	6	0
	Invest in skills and education	DROIDS (3.2)	Low	5	"[1] Feels like maybe the most important recommendation - it's hard to do any of the other recommendations when the organisation lacks skills/understanding.
	More skills are needed for NRAs to engage in procurement methods such as competitive dialogue and innovation partnerships regarding 3rd party data purchases.	Data Strategy Workshop 17-Jun-2025	Low	4	"[2] Also to note that when services, solutions and tech are new, to learn is to do it by working with solving the problem. There can be lack of previous knowledge to provide by education. Therefore, PoCs, pilots and implementations partly provide lessons and skills for NRAs, not only traditional ""education"" and

					""hire skills""."
	Establish a community/forum for NRA representatives with PKI responsibilities, conduct training, workshops, etc.	TIARA (D2.1, D2.2)	Medium	2	Procurement lack technical skills and market awareness and Engineers lack procurement skills. An early dialogue between departments is essential to success and avoid conflicts and worse an invalid ITT which procures data or a service which is not useful
Standards	The importance of digital standards, as well as documented standards - automation in the BIM/AIM/GIS processes	Data Strategy Workshop 17-Jun-2025	High	1	[2] This is exactly what the Directives and Del. Reg. are for: Europe does not tell us which standard to use, but rather that IF we want to cooperate AND we want to exchange data, THEN we should do it according to A standard (the selection/creation thereof happens elsewhere, in committees etc.; cf. DATEX II).
Interoperability	Use of Standardised Data Formats	DROIDS (4.1)	Low	5	[1] Could be combined with other standardisation recommendations above?
Digital products management	Focus on developing mature, well-functioning products, provide clear commercialization opportunities, and engage with end users to understand their needs	TIARA (8)	Medium	4	[1] Is jumping straight to mature products always the right thing to do? Is there value in proving value with a MVP? Perhaps instead, have a mature, well-supported approach to development - don't do a trial and then abandon it, make sure people trust in ongoing support, which then also helps with commercialisation? [2] This recommendation is really three recommendations? [3] How important is the commercialisation aspect? Some use cases might not be commercially viable, but might have safety use cases?
	Understand the data that is procured, especially if not used before. (Implementation phase)	PRESORT (4.1)	Low	4	
	The development of standardized frameworks and collaborative agreements will be crucial for addressing data quality, privacy, and compatibility concerns, ensuring the seamless integration of third-party data into the transportation sector.	PRESORT (3.3)	Medium	0	[1] A (Mobility) Data Space might prove a useful asset here. See also DROIDS D5.1
	Leverage Open Sources	PRESORT (3.3)	Medium	0	[1] but be careful on the sustainability, quality and accuracy of those sources

Data strategy	Development of a clear digitalization strategy: align national and EU initiatives	DROIDS (3.4)	Medium	3	[1] There are different approaches in different countries. From "Digitalize everything" to "Digitalize where and when it makes sense". Also a question of vulnerability if "everything" ends up in the cloud. [2] I added NRA here as stakeholder as they are the ones who ensure the regulation such as RTTI (2022) on data opening is done.
	NRA's Assess the applicability of the current data space instances for mobility	DROIDS (5.1)	Low	0	
Stakeholder management	Establish collaboration and communication between internal and external stakeholders	DROIDS (3.3)	Low	2	
	Establish a Shared Vision: NRAs and third-party data providers should align their data visions, recognizing the value of specific datasets in relation to data quality levels	PRESORT (3.3)	Medium	4	[1] collaboration is important but mutual understanding of the outcomes and the relevance of the data must be understood - Dialogue based procurement can be a great way to improve insight and get the right product
	Establish a feedback process for data consumers to request or design new data products - requests to be routed to relevant business unit	Data Strategy Workshop 17-Jun-2025	High	0	[1] Part of organisation knowledge management process. [2] Data consumers being the road users, service providers, OEMs, research, etc.?
	Future planning dialogue with vehicle Original Equipment Manufacturers (OEMs) (e.g. C2C) covering 10+ year expectations, to ensure investments are future-proofed.	Data Strategy Workshop 17-Jun-2025	Medium	0	
	Talk to other road operators	PRESORT (6)	Medium	0	[1] use the CEDR Data reports to identify experienced NRA's and talk. There are useful use-cases in the PRESORT Deep Dive but references in DROIDS and TIARA too
	Liaise with national stakeholders operating digital representations	Data strategy (chapter 4)	All		[1] Ensures that NRA views are considered and that digital representations are aligned with each other

	used by NRAs or similar to the ones of the NRA				
Data Governance	Ensure backwards-compatibility when feasible	TIARA (D8)		2	[1] Ties to potential issues where users with more information/services need to interact with non-connected or whatever - benefits of things like emergency vehicle notifications become much higher when more people have access.
	Effective data integration is essential for combining diverse data sources to meet objectives (accuracy, consistency, requirements, etc.)	PRESORT (D4.1)	Medium	2	
	Work across sectors to align legal frameworks, technical standards, and operational practices.	TIARA (D8)	Medium	2	[1] In order to have the MNO:s onboard, consider the security solutions already in place for cellular network communication (3GPP-standards).
	Set quality and availability requirements that are easy to check	PRESORT	High	1	[1] no such thing as easy exists...rather use quality metrics with well established and accepted measurement methods Linked to Address Data Quality and Check other data sources
	Define clear consent models, especially for pseudonymised vs. personal data – establish transparent rules for when and how user consent is required	TIARA (D8)	Medium	1	[1] Ties into communication points from previous - how to communicate what it means in an understandable way, when to communicate doesn't feel like its done well at the moment. [2] Important to understand the EU Data Act and take it into account.
	Apply basic principles and processes for ethical use of data	TIARA (D8)	Medium	1	
	The NRA should embed legal, contractual and ethical responsibilities for data accuracy in their operation	TIARA (D6)	Medium	1	[1] Does this mean in the overarching "license to operate" for the NRA, or when contracting with suppliers (or both) [2] To answer the above first comment, this would be for the NRA operational processes, which would include both, if I understood: day-to-day-operations and contracts
	Conduct regular security audits	TIARA (D2.1, D2.2)	Medium	1	
	Governance: work with legal, procurement and audit to elevate data as a deliverable. Communicate	Data Strategy Workshop 17-Jun-2025	Low	1	

	all data policies internally and externally				
	NRA's Decision: Define rulebook (governance model) for the data space	DROIDS 5.1	Low	0	
	Address Data Quality Concerns: NRAs should be mindful of potential data quality issues in less populated regions, where third-party data providers often operate.	PRESORT (D3.3)	High	0	[1] Comment: linked to set quality and availability, and check other data sources
	Data attributes (e.g. accuracy, coverage) align with the requirements: define early	PRESORT (D4.1)	Low	0	
	Check data against other sources	PRESORT	High	0	[1] linked to set quality and availability and also data quality
	Introduce adaptive governance: stakeholder-led audits, certifications – so privacy measures stay effective over time	TIARA (D8)	Medium	0	
Change management and processes	Change Management: Implementing new systems / processes require changes in workflows which is crucial for low maturity organizations to ensure successful adoption.	Data Strategy Workshop 17-Jun-2025	Low	1	[1] Would the TOPIC be here Change management? Not project management. The recommendation relates to organisation workflows and processes. I changed the topic as mentioned.
Use case driven approach	2 Step-by-step framework for use-case identification and validation	PRESORT (5.1)	Medium	1	[1] PRESORT was clear that NRA experience can be very limited. Using a 2-step process will guide the user where experience and capability is lacking
	Adopt a Use-Case-Centred Approach: assess existing data within their organization and identify gaps that third-party data providers can fill.	PRESORT (3.3)	Medium	0	
	Identify digital representation use cases and define the scope/purpose	DROIDS (3.2)	Low	0	[1] Prioritize use cases according to the benefits in the transport system. Start with the low hanging fruits.

	invest in the deployment and operation of the digital representation priority use cases	Data Strategy (chapter 4)	Medium		
	Deploy the most important and useful digital representation use cases with regard to NRA core business in a cost-effective manner	Data Strategy (chapter 4)	Low/ Medium/ High		[1] In the core of any business and organisation: what is the business need and problem, its priority, which is then answered possibly by one of the digital representations; priorities can differ when moving from very local to national in European level.
Architecture	Apply adequate monitoring of PKI infrastructure to detect technical and security issues	TIARA (D2.1, D2.2)	High	1	[1] Invite Business and/or (business/Enterprise) Architects to ensure you identify as many use cases as possible - Ask other NRAs if they have been able to reap the expected benefits from their procurement
	Using the EU C-ITS PKI will allow for effective data exchange across borders	TIARA (D2.1, D2.2)	Medium	0	[1] Not currently worded as a recommendation :)
	Regulation	Data Strategy Workshop 17-Jun-2025	Medium	0	[0] Very urgent especially for the RTTI-related actions [1] This regulation has existed for long, so quite mature compared to other topics [2] Don't forget MMTIS, there may also be relevant data fields there. [3] A lot of collaborations between different kind of stakeholders are ongoing as a result of the updated RTTI regulation and the current revision of the SRTI-regulation. Make use of these collaborations.

6.1.2 Medium priority

Topic	Action	Source (deliverable)	Maturity	Support	Comments
Digital products management	Develop inclusive services by using the human-centered design principles	TIARA (D6)	Medium	1	[1] Are there good standard principles that should be used by Road Operators? Are there sectors that do this well? [2] Answer to the above question: yes, basic principles and research areas are presented in the TIARA deliverable on this matter..
Stakeholder	Prioritize Data Coverage: Given that certain critical data (e.g., traffic	PRESORT (D3.3)	Medium	3	[1] This is probably also important for providing commercialisation opportunities/building a market - companies

managem ent	rules, infrastructure access, road work planning) can only be provided by road authorities, cooperation between NRAs and third-party data providers is crucial to ensure comprehensive data coverage.				can be confident(ish) that governments won't destroy their market. [2] Agree, this is important! [3] Also agree with the above comments, important, partly business models. Data coverage works both ways: public and private have different coverages. For example, ecosystems like Data for Road Safety answer to this on safety related traffic information, i.e. provide wider data coverage.
	Foster Collaboration and Innovation: Regular collaborative workshops and mutual learning meetings will facilitate the exchange of ideas, the exploration of synergies, and the gradual introduction of innovative solutions	PRESORT (D3.3)	Medium	2	
	Identify the road users and involve them in communication and real-world development of the services	TIARA (D6)	Medium	1	[1] This could limit innovation. Perhaps better to test or pilot with them? [2] How broad communication, how to get people to understand what the problems are, right level of language.
	Engage with industry to define what outcomes you want from data, not prescribe how to collect it	PRESORT	Medium	1	[1] Invite Business and/or (business/Enterprise) Architects to ensure you identify as many use cases as possible - Ask other NRAs if they have been able to reap the expected benefits from their procurement
Data Governan ce	Data access control for procured data and its derivatives must balance open access for public use and controlled distribution for private entities.	PRESORT D4.1	Medium	2	
	Integrate privacy-by-design into procurement rules and certification processes (thus, compliance is built in from the start).	TIARA D8	Medium	2	[1] There are different approaches in different countries. From "Digitalize everything" to "Digitalize where and when it makes sense". Also a question of vulnerability if "everything" ends up in the cloud.

Risk Management	Use risk-tiered regulation – based on sensitivity and potential impact of the data	TIARA D8	Medium	3	
	Carry out risk evaluation when communicating and developing ITS/C-ITS services	TIARA (D6) DROIDS (chapter 4)	Medium	2	[1] This should be done in every project/program
Standards	Harmonise privacy standards across borders (GDPR, ePrivacy, ITS).	TIARA (D8)	Low	3	
	Engage in standardization initiatives	DROIDS (3.4)	High	2	[1] Often NRAs don't prioritize to participate and there by misses opportunities for influence. The writers are often a very small group of consultants and some from the industry. (Possible threat?)
	Adopting BIM, OTL and open data standards	Data Strategy Workshop 17-Jun-2025	High	2	[1] Similar as row 18 "The importance of digital standards..."
	Make use of C-Roads (for definitions and standards)	Data Strategy Workshop 17-Jun-2025	Medium	1	[1] Relevant for TIARA, but not for the core of PRESORT and DROIDS, I would say. [2] Agree with the first comment as C-Roads does C-ITS interoperability in Europe. But, digital shadow and twin can use dynamic data in the "upmost" layer? This could be combined with above rows 18 and 30 to "use standards and specifications" which later C-Roads publishes.
	Develop OTL to improve the quality, consistency, and machine readability of the data	Data Strategy Workshop 17-Jun-2025	High	0	[1] An OTL or Object Type Library is a collection of asset types, which can be used in different applications for a consistent understanding and usage of data. [2] Object type libraries
	Adhere to the EU standard for C-ITS PKI	TIARA (D2.1, D2.2)	High	0	[1] An OTL or Object Type Library is a collection of asset types, which can be used in different applications for a consistent understanding and usage of data. [2] Object type libraries
	Transparency of Data Collection and Processing	DROIDS (4.1)	Low	0	

	For national implementation of the RTTI DA - create and agree on national standard DatexII profiles for all datasets early in the process to ensure data interoperability across all municipalities and other players and creation of wider databases (use of DatexII Recommended Reference Profiles as a base)	Data Strategy Workshop 17-Jun-2025	Low	0	
Education and skills	Understand and acquire expertise on C-ITS services, use cases and their limitations		Medium	2	[1] Sources of expertise in a developing technology market - in at least some of TIARA there was a struggle to find case studies I believe.
	For low maturity, Educate / invest in - Digital Transformation (separate to IT Dept.)	Data Strategy Workshop 17-Jun-2025	Medium	1	
	The PKI system for instance is complex and it is recommended that the NRA undertake a concept stage analysis using a rigorous development methodology to establish requirements, architecture and v&v activities.	TIARA	Medium	1	
	Hire skilled resources	TIARA (D2.1, D2.2)	Low	1	[1] This is sometimes hard in a small marketplace, especially with government salaries! [2] Can possibly tie to training (from step 1 though - can you build your own talent pipeline
Digital products management	Public procurement process: guidelines and decision-support on 3rd party data acquisition process	PRESORT (D4.1, D5.1)	Low	2	[1] It is important for road authorities in Europe to work together to align requirements for 3rd party data in order to promote a scalable market for the data providers.
	Phased Implementation	DROIDS (3.2)	Medium	0	

	Strategically Integrate AI and Sensor	PRESORT (D3.3)	Low	1	[1] Specifically on AI, feels low maturity. (Just moved to low priority area so it can be seen, not suggesting its low priority) [2] I would say Medium maturity. Maturity was about "Road operator maturity level of road operation digitalisation". Therefore, I would consider that only when NRA in Medium maturity, would sensor and AI integration be considered, i.e. not the first thing to do if the NRA has low maturity on digitalisation.
Use case driven approach	Third party data may have many use cases in your organisation to share costs	PRESORT	Medium	1	[1] Invite Business and/or (business/Enterprise) Architects to ensure you identify as many use cases as possible - Ask other NRAs if they have been able to reap the expected benefits from their procurement
Data Governance	Independent Certification	DROIDS (4.1)	Low	0	[1] This is data governance related. Similar to regular audits
	SLA monitoring: third-party data providers meet the expected standards for data delivery and quality	PRESORT (D4.1)	High	1	[1] Invite Business and/or (business/Enterprise) Architects to ensure you identify as many use cases as possible - Ask other NRAs if they have been able to reap the expected benefits from their procurement
	Periodic Data Quality Assesments	DROIDS (4.1)	Low	1	
	NRA´s Decision: Define rulebook (governance model) for the data space	DROIDS (5.1)	Low	0	
	NRA´s Select Data Space Service offering/ Data App	DROIDS (5.1)	Low	0	
	System Auditing	DROIDS (4.1)	Medium	0	
	Conduct regular audits	TIARA (D2.1, D2.2)	Medium	0	
	Data Redundancy and Cross-Verification	DROIDS (4.1)	Medium	0	
	Pilot the usefulness of BIM and AIM information within HD maps in cooperation with HD map providers.	Data strategy (chapter 4)	Medium		

	at a minimum ensure that the information related to assets such as GIS information is organised, updated, and complete.				
Stakeholder management	Follow inclusive and transparent communication recommendations	TIARA (D6)	Medium	1	[1] including how to describe data quality, limitations, trust levels etc.
	Engage in concrete cross-border collaboration (e.g. Nordic countries) activities regarding data procurement (wider scale adds innovation incentives) and data analytics (no need to re-invent the wheel)	Data Strategy Workshop 17-Jun-2025	Low	1	[1] Again part of knowledge management and sharing process and European collaboration.
	Foster collaboration among stakeholders, develop innovative policies, and address legal and institutional barriers through strategic planning	TIARA (D2.1, D2.2)	Medium	1	[1] Could be combined with other standardisation recommendations above?
	Encourage collaboration between public administrations and private companies to share costs and expertise.	TIARA (D2.1, D2.2)	Medium	1	[1] This needs a clear way for private companies to profit from it - not sure that is super clear for all use cases - who is paying? (Give everything to google, let them whack ads on everything??)
	Good collaboration between different C-ITS service providers	TIARA (D8)	Medium	0	[1] will require effort and doesn't come naturally [2] What does 'good' look like?
	Enhance supplier collaboration, utilize technology and automation	TIARA (D2.1, D2.2)	Medium	0	
Architecture	Adopt scalable and flexible infrastructure solutions, embrace emerging technologies, and prioritize modular architecture	TIARA (D8)	Medium	1	

	Make key decisions on cloud vs on prem, Data lake vs Data warehouse etc. and prioritize integration processes and authoritative data (reduce duplication). Data collection plan on harvesting data from various applications, systems, service providers etc.	Data Strategy Workshop 17-Jun-2025	Medium	0	[1] Or build your own NRA-cloud
	Leverage managed PKI services to outsource PKI management, reducing the burden on internal teams and ensuring access to experts	TIARA (D2.1, D2.2)	Medium	0	[1] In lieu of skilled resource, this will be necessary
	Catalogue all NRA Data Assets, make available to staff and selected partners. Provide a data dictionary +documentation to authorised data consumers. Categorise regarding level of confidentiality	Data Strategy Workshop 17-Jun-2025	Low	0	
	Data Authentication	DROIDS (4.1)	Low	0	
Requirements	NRA ´s Define Technical and Organisational requirements	DROIDS (5.1)	Low	0	

6.1.3 Low priority

Topic	Action	Source (deliverable)	Maturity	Support	Comments
Architecture	Extend scope beyond C-ITS to apps, infotainment, and navigation platforms (connected services)	TIARA (D8)	Medium	0	[1] Data security should try to plug all possible entries that can be used to feed in unwelcome guests, even if such entries are provided by harmless appearing apps

					[2] i think this is lower priority, at least "infotainment part". Navigation platforms, certainly. [3] Need to be careful about stepping in where there are existing markets
Standards	Standard accuracy for common data, e.g. weather, will help communicate expectations, leading to legal liability	Data Strategy Workshop 17-Jun-2025	Medium	0	
Data Governance	Provide data to Cooperative, connected and automated mobility (CCAM) fleet operators on any actions or changes on the road network due to the processes or contracts of the road operator.		High		[1] Not sure what this topic could be, but I suggest and have added it to data governance separately as priority is low.

6.2 Actions for CEDR

6.2.1 High priority

Topic	Action	Source (deliverable)	Maturity	Support	Comments
Education and skills	Invest in Staff Education	PRESORT (3.3)	Low	6	0
	Invest in skills and education	DROIDS (3.2)	Low	5	[1] Feels like maybe the most important recommendation - it's hard to do any of the other recommendations when the organisation lacks skills/understanding. [2] Also to note that when services, solutions and tech are new, to learn is to do it by working with solving the problem. There can be lack of previous knowledge to provide by education. Therefore, PoCs, pilots and implementations partly provide lessons and skills for NRAs, not only traditional "education" and "hire skills".

	Establish a community/forum for NRA representatives with PKI responsibilities, conduct training, workshops, etc.	TIARA (D2.1, D2.2)	Medium	2	[1] Again part of knowledge management and sharing process and European collaboration topic. Possible to combine?
Standards	Open standards among stakeholders should be promoted at an EU level in order to reduce dependency on proprietary technologies and patents	TIARA	Medium	6	[1] At an European level? [2] This is exactly what the Directives and Del. Reg. are for: Europe does not tell us which standard to use, but rather that IF we want to cooperate AND we want to exchange data, THEN we should do it according to A standard (the selection/creation thereof happens elsewhere, in committees etc.; cf. DATEX II). [3] I added Member State / Ministries as a stakeholder as they to promote and be part of any legislation preparation.
	The importance of digital standards, as well as documented standards - automation in the BIM/AIM/GIS processes	Data Strategy Workshop 17-Jun-2025	High	1	[1] Similar as row 30 "Adopting BIM, OTL and open data standards"
	Align with National Standards	DROIDS (3.2)	Low	1	[1] First try to align with European Standards, if not available, then go for National Standards [2] There can also be International Standards besides just European and National, agree that European Standards are likely to be prioritised as long as they're not outdated relative to a relevant international one
Interoperability	Use of Standardised Data Formats	DROIDS (4.1)	Low	5	[1] Could be combined with other standardisation recommendations above?
Data strategy	Development of a clear digitalization strategy: align national and EU initiatives	DROIDS (3.4)	Medium	3	[1] There are different approaches in different countries. From "Digitalize everything" to "Digitalize where and when it makes sense". Also a question of vulnerability if "everything" ends up in the cloud. [2] I added NRA here as stakeholder as they are the ones who ensure the regulation such as RTTI (2022) on data opening is done.

Stakeholder management	Establish a feedback process for data consumers to request or design new data products - requests to be routed to relevant business unit	Data Strategy Workshop 17-Jun-2025	High	0	[1] Part of organisation knowledge management process. [2] Data consumers being the road users, service providers, OEMs, research, etc.?
Data Governance	Apply basic principles and processes for ethical use of data	TIARA (D6)	Medium	1	
	The NRA should embed legal, contractual and ethical responsibilities for data accuracy in their operation	TIARA (D6)	Medium	1	[1] Does this mean in the overarching "license to operate" for the NRA, or when contracting with suppliers (or both) [2] To answer the above first comment, this would be for the NRA operational processes, which would include both, if I understood: day-to-day-operations and contracts
	Governance: work with legal, procurement and audit to elevate data as a deliverable. Communicate all data policies internally and externally	Data Strategy Workshop 17-Jun-2025	Low	1	
	NRA's Decision: Define rulebook (governance model) for the data space	DROIDS (5.1)	Low	0	
Use case driven approach	Identify most important digital representations and their types based on European, national and CEDR priorities	Data strategy (chapter 4)	Low/ Medium/ High		[1] In the core of any business and organisation: what is the business need and problem, its priority, which is then answered possibly by one of the digital representations; priorities can differ when moving from very local to national in European level.

6.2.2 Medium priority

Topic	Action	Source (deliverable)	Maturity	Support	Comments
Stakeholder management	Prioritize Data Coverage: Given that certain critical data (e.g., traffic rules, infrastructure access, road work planning) can only be provided	PRESORT (D3.3)	Medium	3	[1] This is probably also important for providing commercialisation opportunities/building a market - companies can be confident(ish) that governments won't destroy their market.

	by road authorities, cooperation between NRAs and third-party data providers is crucial to ensure comprehensive data coverage.				[2] Agree, this is important! [3] Also agree with the above comments, important, partly business models. Data coverage works both ways: public and private have different coverages. For example, ecosystems like Data for Road Safety answer to this on safety related traffic information, i.e. provide wider data coverage.
Data Strategy	CEDR Decision: Deploy a "mobility" data space strategy as an enabler for digital road operations	DROIDS (5.1)	High	5	[1] mobility data space => more maturity needed than for SRTI and "developing mature products" [2] I changed the TOPIC from Project Management to the current Data Strategy
Standards	Adopting BIM, OTL and open data standards	Data Strategy Workshop 17-Jun-2025	High	2	[1] Similar as row 18 "The importance of digital standards..."
	Make use of C-Roads (for definitions and standards)	Data Strategy Workshop 17-Jun-2025	Medium	1	[1] Relevant for TIARA, but not for the core of PRESORT and DROIDS, I would say. [2] Agree with the first comment as C-Roads does C-ITS interoperability in Europe. But, digital shadow and twin can use dynamic data in the "upmost" layer? This could be combined with above rows 18 and 30 to "use standards and specifications" which later C-Roads publishes.
	Adhere to the EU standard for C-ITS PKI	TIARA (D2.1, D2.2)	High	0	[1] An OTL or Object Type Library is a collection of asset types, which can be used in different applications for a consistent understanding and usage of data. [2] Object type libraries
Digital products management	Phased Implementation	DROIDS (3.2)	Medium	0	[2] I added NRA here as first stakeholder as they are the ones doing the implementations. CEDR mainly for knowledge sharing?
	Strategically Integrate AI and Sensor	PRESORT (D3.3)	Low	1	[1] Specifically on AI, feels low maturity. (Just moved to low priority area so it can be seen, not suggesting its low priority) [2] I would say Medium maturity. Maturity was about "Road operator maturity level of road operation digitalisation". Therefore, I would consider that only when NRA in Medium maturity, would sensor and AI integration be considered, i.e. not the first thing to do if the NRA has low maturity on digitalisation.

Data Governance	CEDR Decision: Central (EU) vs Decentral (Member state) Data Governance Body	DROIDS (5.1)	Low	0	[1] Non-EU members have to be acknowledged [2] Maybe not a CEDR decision but CEDR to provide guidance? Compare to RTTI data where in regulation requirement to agree between member states on the data quality etc.
Stakeholder management	Foster collaboration among stakeholders, develop innovative policies, and address legal and institutional barriers through strategic planning	TIARA (D2.1, D2.2)	Medium	1	[1] Could be combined with other standardisation recommendations above?
	Encourage collaboration between public administrations and private companies to share costs and expertise.	TIARA (D2.1, D2.2)	Medium	1	[1] This needs a clear way for private companies to profit from it - not sure that is super clear for all use cases - who is paying? (Give everything to google, let them whack ads on everything??)
	CEDR Decision: Deploy a cocreation methodology for informed decision making and effective collaboration	DROIDS (5.1)	Low	0	[1] Co-creation with who? [2] Co-creation of what, digital representations? Could be similar as data governance (row 36) and knowledge management processes?
Architecture	Adopt scalable and flexible infrastructure solutions, embrace emerging technologies, and prioritize modular architecture	TIARA (D8)	Medium	1	
	Leverage managed PKI services to outsource PKI management, reducing the burden on internal teams and ensuring access to experts	TIARA (D2.1, D2.2)	Medium	0	[1] In lieu of skilled resource, this will be necessary
Requirements	NRA ´s Define Technical and Organisational requirements	DROIDS (5.1)	Low	0	

6.2.3 Low priority

Topic	Action	Source (deliverable)	Maturity	Support	Comments
	None				

6.3 Specific actions for the European Data Spaces

6.3.1 High priority

Topic	Action	Source (deliverable)	Maturity	Support	Comments
Standards	Open standards among stakeholders should be promoted at an EU level in order to reduce dependency on proprietary technologies and patents	TIARA	Medium	4	[1] At an European level? [2] This is exactly what the Directives and Del. Reg. are for: Europe does not tell us which standard to use, but rather that IF we want to cooperate AND we want to exchange data, THEN we should do it according to A standard (the selection/creation thereof happens elsewhere, in committees etc.; cf. DATEX II). [3] I added Member State / Ministries as a stakeholder as they to promote and be part of any legislation preparation.
	Align with National Standards	DROIDS (3.2)	Low	1	[1] First try to align with European Standards, if not available, then go for National Standards [2] There can also be International Standards besides just European and National, agree that European Standards are likley to be prioritised as long as they're not outdated relative to a relevant international one
Interoperability	Use of Standardised Data Formats	DROIDS (4.1)	Low	4	[1] Could be combined with other standardisation recommendations above?
Digital products management	Focus on developing mature, well-functioning products, provide clear commercialization opportunities,	TIARA (8)	Medium	4	[1] Is jumping straight to mature products always the right thing to do? Is there value in proving value with a MVP? Perhaps instead, have a mature, well-supported approach to development - don't do a trial and then abandon it, make sure people trust in ongoing

	and engage with end users to understand their needs				support, which then also helps with commercialisation? [2] This recommendation is really three recommendations? [3] How important is the commercialisation aspect? Some use cases might not be commercially viable, but might have safety use cases?
	Create infrastructure templates for onboarding of new pipelines and products	Data Strategy Workshop 17-Jun-2025	High	0	
	The development of standardized frameworks and collaborative agreements will be crucial for addressing data quality, privacy, and compatibility concerns, ensuring the seamless integration of third-party data into the transportation sector.	PRESORT (3.3)	Medium	0	[1] A (Mobility) Data Space might prove a useful asset here. See also DROIDS D5.1
	Leverage Open Sources	DROIDS (3.3)	Medium	0	[1] but be careful on the sustainability, quality and accuracy of those sources
Data strategy	Development of a clear digitalization strategy: align national and EU initiatives	DROIDS (3.4)	Medium	3	[1] There are different approaches in different countries. From "Digitalize everything" to "Digitalize where and when it makes sense". Also, a question of vulnerability if "everything" ends up in the cloud. [2] I added NRA here as stakeholder as they are the ones who ensure the regulation such as RTTI (2022) on data opening is done.
	NRA 's Assess the applicability of the current data space instances for mobility	DROIDS (5.1)	Low	0	
Stakeholder management	Establish collaboration and communication between internal and external stakeholders	DROIDS (3.3)	Low	2	
	Future planning dialogue with vehicle Original Equipment Manufacturers (OEMs) (e.g. C2C)	Data Strategy Workshop 17-Jun-2025	Medium	0	

	covering 10+ year expectations, to ensure investments are future-proofed.				
Data Governance	Ensure backwards-compatibility when feasible	TIARA (D8)		2	[1] Ties to potential issues where users with more information/services need to interact with non-connected or whatever - benefits of things like emergency vehicle notifications become much higher when more people have access.
	Effective data integration is essential for combining diverse data sources to meet objectives (accuracy, consistency, requirements, etc.)	PRESORT (D4.1)	Medium	2	
	Work across sectors to align legal frameworks, technical standards, and operational practices.	TIARA (D8)	Medium	2	[1] In order to have the MNO:s onboard, consider the security solutions already in place for cellular network communication (3GPP-standards).
	Define clear consent models, especially for pseudonymised vs. personal data – establish transparent rules for when and how user consent is required	TIARA (D8)	Medium	1	[1] Ties into communication points from previous - how to communicate what it means in an understandable way, when to communicate doesn't feel like its done well at the moment. [2] Important to understand the EU Data Act and take it into account.
	NRA´s Decision: Define rulebook (governance model) for the data space	TIARA (D8)	Low	0	
	Introduce adaptive governance: stakeholder-led audits, certifications – so privacy measures stay effective over time	TIARA (D8)	Medium	0	
Use case driven approach	Adopt a Use-Case-Centred Approach: assess existing data within their organization and identify gaps that third-party data providers can fill.	PRESORT (3.3)	Medium	0	

Architecture	Apply adequate monitoring of PKI infrastructure to detect technical and security issues	TIARA (D2.1, D2.2)	High	1	[1] Invite Business and/or (business/Enterprise) Architects to ensure you identify as many use cases as possible - Ask other NRAs if they have been able to reap the expected benefits from their procurement
	Using the EU C-ITS PKI will allow for effective data exchange across borders	TIARA (D2.1, D2.2)	Medium	0	[1] Not currently worded as a recommendation :)

6.3.2 Medium priority

Topic	Action	Source (deliverable)	Maturity	Support	Comments
Digital products management	Develop inclusive services by using the human-centred design principles	TIARA (D6)	Medium	1	[1] Are there good standard principles that should be used by Road Operators? Are there sectors that do this well? [2] Answer to the above question: yes, basic principles and research areas are presented in the TIARA deliverable on this matter..
Stakeholder management	Foster Collaboration and Innovation: Regular collaborative workshops and mutual learning meetings will facilitate the exchange of ideas, the exploration of synergies, and the gradual introduction of innovative solutions	PRESORT (3.3)	Medium	2	
	Data access control for procured data and its derivatives must balance open access for public use and controlled distribution for private entities.	PRESORT (D4.1)	Medium	2	
	Integrate privacy-by-design into procurement rules and certification	TIARA (D8)	Medium	2	[1] There are different approaches in different countries. From "Digitalize everything" to "Digitalize where and when it makes

Data Governance	processes (thus, compliance is built in from the start).				sense". Also a question of vulnerability if "everything" ends up in the cloud.
	Use risk-tiered regulation – based on sensitivity and potential impact of the data	TIARA (D8)	Medium	3	
Risk Management	Harmonise privacy standards across borders (GDPR, ePrivacy, ITS).	TIARA (D8)	Low	3	
Standards	Develop OTL to improve the quality, consistency, and machine readability of the data	Data Strategy Workshop 17-Jun-2025	High	0	[1] An OTL or Object Type Library is a collection of asset types, which can be used in different applications for a consistent understanding and usage of data. [2] Object type libraries
	Transparency of Data Collection and Processing	DROIDS (4.1)	Low	0	
	For national implementation of the RTTI DA - create and agree on national standard DatexII profiles for all datasets early in the process to ensure data interoperability across all municipalities and other players and creation of wider databases (use of DatexII Recommended Reference Profiles as a base)	Data Strategy Workshop 17-Jun-2025	Low	0	
	Independent Certification	DROIDS (4.1)	Low	0	[2] This is data governance related. Similar to regular audits
Data Governance	SLA monitoring: third-party data providers meet the expected standards for data delivery and quality	PRESORT (4.1)	High	1	[1] Invite Business and/or (business/Enterprise) Architects to ensure you identify as many use cases as possible - Ask other NRAs if they have been able to reap the expected benefits from their procurement
	Periodic Data Quality Assessments	DROIDS (4.1)	Low	1	

	CEDR Decision: Central (EU) vs Decentral (Member state) Data Governance Body	DROIDS (5.1)	Low	0	[1] Non-EU members have to be acknowledged [2] Maybe not a CEDR decision but CEDR to provide guidance? Compare to RTTI data where in regulation requirement to agree between member states on the data quality etc.
	NRA´s Decision: Define rulebook (governance model) for the data space	DROIDS (5.1)	Low	0	
	NRA´s Select Data Space Service offering/ Data App	DROIDS (5.1)	Low	0	
	Conduct regular audits	TIARA (D2.1, D2.2)	Medium	0	
	Data Redundancy and Cross-Verification	DROIDS (4.1)	Medium	0	
	Establish / participate in interest groups for C-ITS service providers	TIARA (D2.1, D2.2)	Medium	0	
Stakeholder management	Adopt scalable and flexible infrastructure solutions, embrace emerging technologies, and prioritize modular architecture	TIARA (D8)	Medium	1	
Architecture	Make key decisions on cloud vs on prem, Data lake vs Data warehouse etc. and prioritize integration processes and authoritative data (reduce duplication). Data collection plan on harvesting data from various applications, systems, service providers etc.	Data Strategy Workshop 17-Jun-2025	Medium	0	
	Leverage managed PKI services to outsource PKI management, reducing the burden on internal teams and ensuring access to experts	TIARA (D2.1, D2.2)	Medium	0	[1] In lieu of skilled resource, this will be necessary

	Catalogue all NRA Data Assets, make available to staff and selected partners. Provide a data dictionary +documentation to authorised data consumers. Categorise regarding level of confidentiality	Data Strategy Workshop 17-Jun-2025	Low	0	[1] This is why a (Mobility) Data Space exists.
	Data Authentication	DROIDS (4.1)	Low	0	

6.3.3 Low priority

Topic	Action	Source (deliverable)	Maturity	Support	Comments
Architecture	Extend scope beyond C-ITS to apps, infotainment, and navigation platforms (connected services)	TIARA (D8)	Medium	0	[1] Data security should try to plug all possible entries that can be used to feed in unwelcome guests, even if such entries are provided by harmless appearing apps [2] i think this is lower priority, at least "infotainment part". Navigation platforms, certainly. [3] Need to be careful about stepping in where there are existing markets
Standards	Standard accuracy for common data, e.g. weather, will help communicate expectations, leading to legal liability	Data Strategy Workshop 17-Jun-2025	Medium	0	
Data Governance	Provide data to Cooperative, connected and automated mobility (CCAM) fleet operators on any actions or changes on the road network due to the processes or contracts of the road operator.		High		[1] Not sure what this topic could be, but I suggest and have added it to data governance separately as priority is low.

6.4 Data space design principles for digital road operations

The data space design principles as part of the action plan as shown in Figure 4 is shown in Table 2 below.

Table 2 Summary of design principles for data spaces

Design principles	DSSC building blocks	Action Group in Roadmap
Reusability of Data	Data Interoperability	Implement interoperability and utilise standards
Pursuit Quality by Design	Governance	Develop a data governance and risk management framework.
Adaptable data space governance framework	Governance	Develop a data governance and risk management framework.
Establish a fit-for-purpose contractual framework	Legal and Governance	Develop and purchase data and services in accordance with established standards, guidelines, and design principles.
Ensure Data Interoperability in data spaces	Data Interoperability Building Blocks	Implement interoperability and utilise standards
Incentives and Synergies Between Data Space Participants	Participant management, Use case development	Carry out stakeholder collaboration and prioritise use cases.
Ensure Compliance with EU Legal Framework (Appendix 6.7) and Norms	Legal and Governance	Develop a data governance and risk management framework.
Discoverability, Availability, and Accessibility of Data	Publication and discovery	Develop and purchase data and services in accordance with established standards, guidelines, and design principles.
Transparency	Provenance and traceability	Develop a data governance and risk management framework.
Establishing Trust and Security in Data spaces.	Trust framework	Implement a trust framework
Ensure Participants Rights Through Data Sovereignty	Trust framework, Identity and attestation framework, Access & usage policies enforcement,	Implement a trust framework
Promote Participation Through Inclusivity	Participation management	Carry out stakeholder collaboration and prioritise use cases.
Promote Environmental Sustainability	Develop and purchase data and services in accordance with established standards, guidelines, and design principles.	Value creation services

6.5 Co-creation in the development cycle for digital road operations

The co-creation process in the development cycle, as outlined in the action plan, is illustrated in Figure 12 below.

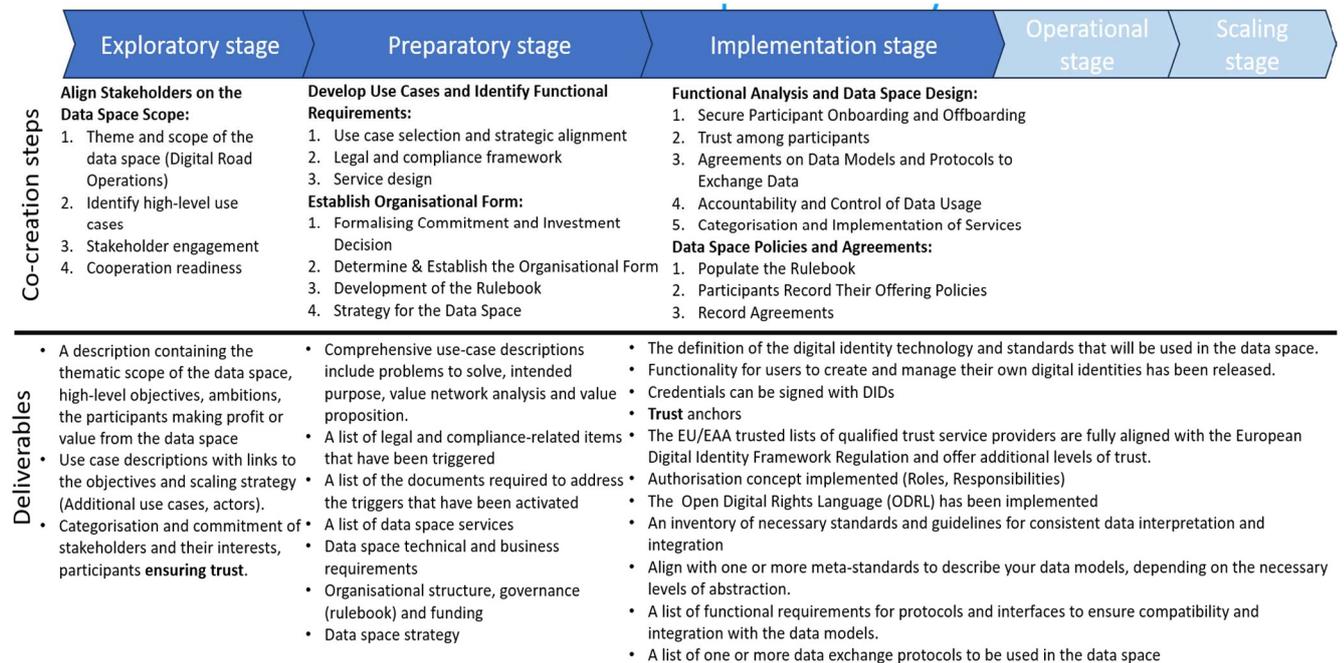


Figure 12 Co-creation in the development cycle

6.6 Deployment stages for the European data space for NRA

The description of the actions required to deploy the data strategy in a standard form (e.g. as we did in Finland with Ilkka for the road operator automated driving facilitation; the standard form should address the expertise needed, the approximate magnitude of costs involved, links and scheduling with regard to other actions listed to be aware of the synergies)

The development cycle as part of the action plan for setting up the dataspace for NRA mainly **comprises of five stages exploratory stage, preparatory stage, implementation stage, operational stage, and scaling stage**. Each of the stages are briefly described below. These stages are also extensively described in the appendix section of this report.

Exploratory Stage (M1-M12). The initial stage is where the potential and viability of a data space are explored. Activities include identifying and attracting stakeholders, collecting requirements, and discussing use cases.

is the initial stage from which the development of a data space begins. At this stage, there isn't an actual data space initiative yet, but rather group of actors seeking to identify other potentially interested stakeholders and draw them in. Other activities related to this phase include early conceptualisation of use cases, gathering requirements, and reviewing existing industry practices and standards.

Preparatory Stage. This stage begins when there is a critical mass of committed stakeholders and an agreement to move forward. These stakeholders develop use cases and prepare for implementation.

Implementation Stage. At this stage, the initiative has a detailed project plan, milestones, and

resources for developing its governance framework and infrastructure. It typically involves a data space pilot. The stakeholders become data space participants when they commit to the governance framework.

Operational Stage. This stage starts when the infrastructure and governance framework are tested, participants are onboarded and the first use case becomes operational, with data flowing between providers and recipients.

Scaling Stage. The final stage, where the data space consistently gains new participants and embraces new use cases, achieving financial and operational sustainability.

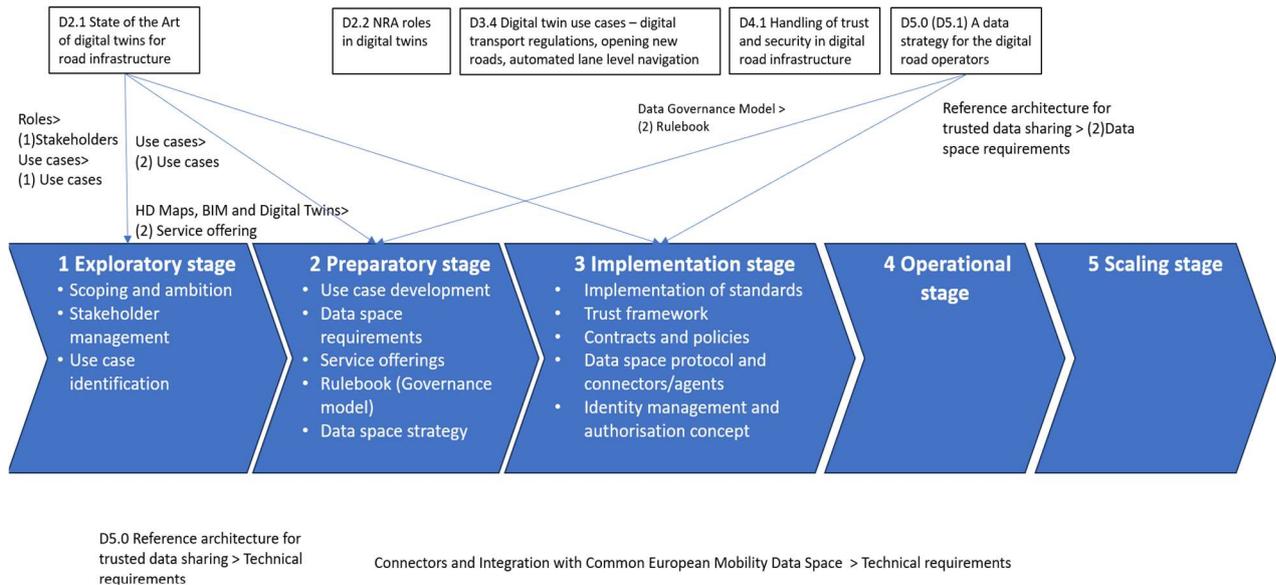


Figure 11 Development cycle for a data space (Implementation Roadmap)

6.6.1 Exploratory stage

Align stakeholders on the scope of the data space. The purpose of this process is to create a 'coalition of the willing' among different stakeholders supporting digital road operations who want to analyse the extent to which they are prepared to share data within or across data spaces. Successful data spaces require strong stakeholder alignment from the start. This process ensures all involved parties share a common understanding of the data space’s purpose, scope, and governance principles, thereby reducing misalignment and accelerating decision-making.

Steps	Questions	DSSC Building Block	Outcome
1. Theme and scope of the data space	What is the data space’s thematic scope?	Business Model. Explain the type of problems within digital road operations that the data space intends to solve.	The challenges to be addressed by the data space for CEDR, NRAs and other stakeholders
Objective Understand the general theme and scope of the data space, including industry, supply chain, or societal problems it	What are the objectives of the data space?	Business Model. Explain the value creation from a data space supporting relevant use cases	The high-level objectives that allow for steering in use case selection for CEDR and NRAs

aims to address.	What are the data space's growth ambitions?	Business Model. Defining the ambitions for digital road operations supported by data spaces across the EU member states	Number of member states Number of 3 rd party data providers Number of use cases Interoperability with other relevant data spaces (e.g. green deal, smart cities)
	What are the data space's profit ambitions?	Business Model. An important practical consideration is determining whether the data space will operate on a for-profit or non-profit basis.	An overview of which parties will make a profit from the data space
2. Identify high-level use cases Objective Identify and define the high-level use cases the data space will support. Develop scenarios to illustrate potential applications and demonstrate the value that the data space can create.	What high-level use cases should the data space support?	Use Case Development Identifying and describing high-level use cases that demonstrate the data space's practical value and applications.	A list of use cases prioritised by CEDR/NRAS
	How do these use cases contribute to the overarching goals and scope of the data space initiative?	Business Model Provide an understanding of the overarching goals and strategic decisions of the data space. It emphasises the importance of defining how each identified use case supports and advances the broader goals, mission, scope, effects, and impacts defined for the data space.	Goals, mission, scope, effects, and impacts defined for the data space confirmed by CEDR/NRAS
	How will the data space attract and scale its user base, data providers, and service offerings to achieve critical mass, where it reaches a sufficient scale to sustain itself and generate significant value?	Business Model Aligning the value propositions of multiple organisations. This aids in understanding the strategy for growing the user base, attracting data providers, and expanding service offerings.	Additional use cases or value adding services
3. Stakeholder engagement	Who are the stakeholders that are directly and indirectly	Participation Management Identifying all relevant stakeholders and their relationship to the data	Stakeholder list including their role (Data providers, data consumers, data rights)

<p>Objective</p> <p>Identify and engage with relevant stakeholders who will contribute to and benefit from the data space. Assess their willingness to participate, their roles, and their identities within the data space</p>	affected by the data space?	space.	holders, intermediaries, operators, etc.)
	Which of these stakeholders will actually participate in the data space?	<p>Participation Management</p> <p>Identify which stakeholders are willing to engage and clarifying their roles. Identifying the roles of different stakeholders helps organise effective collaboration within the data space.</p>	List of interested parties (secondary stakeholders)
	What are the objectives of participation?	<p>Participation Management</p> <p>Defining goals and expectations for stakeholder participation.</p>	Lol from the stakeholders
	What are the relevant identities in the data space?	<p>Participation Management</p> <p>Identify the types of actors that may participate in the data space and specifies the types of participants who can use it.</p> <p>Identity and Attestation Management</p> <p>Explain how verified identities ensure trust and security within the data space.</p>	High-level conformity assessment scheme
<p>4. Cooperation readiness</p> <p>Objective</p> <p>Determine whether to proceed with creating the data space based on organisational readiness and strategic alignment.</p>	Do the organizations involved want to establish a data space?	<p>Organisational form and Governance Authority</p> <p>Assists data space initiative members in understanding their legal formalisation options. Initially, the data space must assess stakeholder commitment and readiness for formalisation. If stakeholders are committed, cooperation agreements are established; if not, the process halts for re-evaluation of the data space's suitability.</p>	Signed cooperation agreements.

6.6.2 Preparatory stage

6.6.2.1 Develop Use Cases and Identify Functional Requirements

This development process provides further detail on the fundamentals established in the first process, *Align Stakeholders on the Data Space Scope*. Therefore, there is one fundamental

question divided into two sub-questions that must be considered during this process:

To what extent can the use cases create a viable data space?

- What value will the use cases create for each stakeholder, and how?
- What must be arranged (technically, legally, and otherwise) to enable value creation for the use cases?

Defining a 'viable data space' for all data spaces in a single term is challenging. Therefore, it is advisable to establish how this term is defined within the data space initiative. Possible conditions for a viable data space might include:

- The data space can function without the need for public funding.
- There is a positive business case for all participants in the data space.
- The data space can reach critical mass.

Steps	Questions	DSSC Building Block	Outcome
<p>1. Use case selection and strategic alignment</p> <p>Objective</p> <p>Define the initial use case(s) and associated stakeholders that will allow the data space to start. This implies that choices need to be made on which use cases are developed first and which will be developed later.</p>	<p>Which use cases should the data space focus on first, and which are to be developed in the future?</p>	<p>Business Model and Use case Development.</p> <p>It is important to identify and prioritise the use cases that create enough value for the data space to get started.</p>	<p>High priority use cases decided by CEDR/NRAs</p> <p>(The list of high-level use cases drafted in Align Stakeholders on the Data Space Scope - Step 2, needs to be refined and ranked according to:</p> <ul style="list-style-type: none"> • Value created: consider the cost of development and margins • Easy of development • Stakeholder interests • Other parameters agreed upon by the stakeholders <p>Once the list is complete, select the top use case(s) to further develop in the data space.)</p>
	<p>What is the purpose or problem to be solved by the use case (business, societal, and/or environmental</p>	<p>Use case development</p> <p>Explain how the purpose and value of a use case are integral to its core design and how these aspects are validated during the refinement step.</p>	<p>The problem addressed in each use case defined by CEDR, NRAs</p> <p>Definition of the purpose of the use case and it's alignment mend with</p>

	value)?		the data space purpose.
	Which participants or actors are directly involved in which use cases, and what roles do they play?	<p>Contractual Framework Define interoperable, automated, and scalable agreements</p> <p>Organizational Form and Governance Authority Define roles, responsibilities, and relationships of participants to ensure effective collaboration and governance.</p> <p>Use case Development Describe a process for agreeing on the participants of a specific use case and their roles within that use case.</p>	<p>A comprehensive description of the use case and preferably a value network analysis.</p> <p>A detailed description of the offerings of data products and services between the participants, including, if applicable, the physical flows of goods and services and monetary transactions.</p>
	What benefits do these use cases offer to these participants?	<p>Business Model Outline how the value propositions of participants influence the business model of the data space. It is important to outline the tangible benefits, value propositions, and expected outcomes that participants can derive from their involvement in each use case, providing insights into individual and collaborative business models. Therefore, establish the business model for each participant and determine how these models contribute to the collaborative value created.</p> <p>Use case development Describe how the value propositions for use case participants are part of the core design of a use case and how these are confirmed in the refinement step.</p>	<p>Value proposition for each use case including:</p> <ul style="list-style-type: none"> • The value the participant adds to the use case. • The actions each participant undertakes to deliver that value (e.g. to whom the participant offers what). • The cost model of delivery, including the expenses associated with executing the activities. • The revenue model of delivery, detailing the revenue generated by the activities. <p>The recipients of the participant's offerings.</p>
2. Legal and compliance framework	What legal agreements are necessary for governing data	<p>Contractual Framework</p> <p>Discuss factors that may trigger the application of</p>	A list of legal and compliance-related items (Appendix 6.1) that have been

<p>Objective</p> <p>Ensure adherence to legal and regulatory requirements for secure and compliant data sharing.</p>	<p>sharing, usage rights, and liabilities across different use cases?</p>	<p>various legal requirements, provides pointers on relevant rules and regulations for different use cases, and offers insights into which agreements might be necessary.</p>	<p>triggered provided by CEDR/NRA's</p> <p>A list of the documents required to address the triggers that have been activated. Be very clear about the level at which these agreements should be made. Agreements for a data space in general, for individual users, or for users interacting with one another. Which Service Level Agreements (SLAs) pertain to the data space, and which are for a service operator?</p>
<p>3. Service design</p> <p>Objective</p> <p>Define how the use cases and their data products will be offered in the data space, and support the identified use cases by establishing the necessary federation, participant agent, and value creation services, as well as the parties responsible for delivering these services.</p>	<p>What are the core services required within the data space, and how do they relate to the business models of the use cases and data space itself?</p>	<p>The core services are the minimum services necessary to facilitate the functioning of the data space and its (initial) use case(s). These may include federation, participant agent, value creation services, or any combination thereof.</p> <p>The Business Model building blocks differentiate between federation, participant agent, and value creation services. Services are defined as the mechanisms through which value is created and are an essential part of the business model.</p> <p>The Value Creation Services building block shows the different technical capabilities that these services can provide to generate value from data sharing.</p>	<p>A list of services that the data space and its participants need to offer to one another in order to ensure the data space can exist.</p> <p>Each data space possesses its own core service. For Smart Connected Supplier Network (SCSN) core services are:</p> <p>SCSN foundation: Maintaining and developing new messages</p> <p>SCSN foundation: Maintaining and updating the data standard/models</p> <p>SCSN foundation: Monitoring and updating the rulebook</p> <p>Service Providers: Delivering participant agents (thus enabling access to the data space and the ability to send messages)</p>
	<p>What value-added services does the data space offer (in</p>	<p>Value Creation Services Provide an approach for managing services that extend the core functionality</p>	<p>A list of services that the data space and its participants need to offer one another to</p>

	<p>addition to the core services) to support the use cases, and why are these services important?</p>	<p>required by the use cases to create additional value. These services might include data processing, integration, or user experience to maximise the value generated.</p>	<p>facilitate the provision of use cases.</p> <p>For SCSN, the value-added services are:</p> <p>SCSN Foundation: Onboarding service providers</p> <p>SCSN Foundation: Orchestration services to bring in new participants</p> <p>Service Providers: Onboarding end-users</p>
	<p>What are the requirements to integrate and operationalise the value-added services effectively within and or across data spaces?</p>	<p>Value Creation Services Offer a framework that addresses the requirements identified by various participants in the data space.</p>	<p>The technical requirements for the data space (e.g. data volume, granularity, and extent of the data models, as well as the extent and detail of the catalogues.)</p>
	<p>Which parties will offer what services?</p>	<p>Business Model Show how this question leads to a make-or-buy decision. There might be parties and/or data spaces in the market that offer the services needed to make the data space work.</p> <p>Intermediaries and Operators Identify to whom these services would be provided: only to companies and organisations, or also to individuals?</p>	<p>Business requirements of the data space.</p> <p>Decision on buy or make the technical solution aligned with the technical requirements</p> <p>Overview of the essential parties for your business model and the power dynamics between the participants, the service providers, and the data space authority is crucial.</p>
	<p>How is data used by each use case within the data space and/or across data spaces, and what types of data are essential for its operation?</p>	<p>Data Space Offering Provide guidance for data space participants in creating resources and data product offerings. It helps determine data sources, formats, and quality requirements necessary to support use case activities.</p> <p>Use Case Development Explain how such data products can either be developed within the data</p>	<p>A complete picture of how data services and data products move around in the data space.</p> <p>Connecting this to the use cases and services offered in the data space should give you an overview of how various parties interact within the data space.</p>

		space or obtained from another data space for a cross-data space joint use case.	
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6.6.2.2 Establish organisational form

What is the result of the process:

- Formalisation in collaboration, by defining the organisational form.
- The parameters of the governance framework, along with the roles and responsibilities in the data space, become clear.

Who should take action regarding the result:

- The establishing parties that have been (self-)determined to fill and enforce the rulebook.

What can the actors do with the result:

- Participants can start joining the data space.
- The establishing parties have an organisational form through which further agreements can be made.

Steps	Questions	DSSC Building Block	Outcome
1. Formalise Commitment and Investment Decision Objective Formalise the division of roles and responsibilities in the data space.	What are the roles and responsibilities of the data space founders that will become part of the governance authority?	Organisational Form and Governance Authority The establishment of the data space requires the parties involved to agree to commit funds, capital, or in-kind contributions.	Resource and funding commitment
	What is the business model for the governance authority?	Business Model Provide guidelines for considering new business models and successfully developing one, outlining financial and sustainability strategies for the governance authority in particular.	Agree up on profit and losses, organisational form, and funding
2. Determine and Establish the Organisational form Objective Create the data space and formalise its existence, thereby establishing the governance authority.	What organisational form is chosen for the data space?	Organizational Form and Governance Authority Offers an overview of different types of governance authorities based on the legal organisational form and best practices in corporate governance.	Decision regarding the organisational form
	What governance authority will be established?	Organizational Form and Governance Authority Provides an overview of different types of governance authorities	Establish and formalise the governance authority of the data space

		based on the legal organisational form and best practices in corporate governance.	
	What are the data space agreements necessary for the foundation of the data space?	Contractual Framework Describes the different data space agreements that must be established to create the data space.	Confirmation of a funding and accession
<p>3. Development of the Rulebook</p> <p>Objective</p> <p>Create a comprehensive rulebook that prescribes the internal rules by which the data space is governed.</p>	What needs to be considered when creating the rulebook for a data space?	Organizational Form and Governance Authority Distinguishes between external rules (e.g., laws and regulations) and internal founding agreements, policies, terms of use, and similar documentation.	Create the fundamental policies that form part of the rulebook.
	Which legislative frameworks/triggers must be considered for the internal rules?	Regulatory Compliance Ensure compliance with relevant legislation and regulations throughout the data space's lifecycle.	Use Cases and Identify Functional Requirements – adhering to regulations
	Which legislative frameworks are relevant when drafting contractual clauses?	Contractual Framework Address data protection, intellectual property, cybersecurity, risk management policies, and the technical standards required by law.	Use Cases and Identify Functional Requirements - methods for adhering to regulations.
	Which activities will the governance authority perform to run the data space?	Business Model An overview of the roles of the governance authority concerning the business model. Organizational Form and Governance Authority and Participation Management Address governance topics related to the activities of the governance authority.	Use Cases and Identify Functional Requirements - roles and responsibilities of each party involved in the data space.
	What are the processes through which the governance authority should perform their	Business Model the data space's business model is attractive from the perspective of the organisations involved in the governance authority,	Use Cases and Identify Functional Requirements - processes for executing these responsibilities will be

	duties, and how should they be monitored and reviewed?	<p>guaranteeing that participants are compensated for their responsibilities and remain engaged in their roles.</p> <p>Organizational Form and Governance Authority and Participation Management</p> <p>Defines the legal agreements pertaining to the governance authority in the rulebook.</p>	designed.
	How does the data space manage legal aspects such as privacy policy, data protection policy and cybersecurity policy?	<p>Regulatory Compliance</p> <p>Guidance on establishing comprehensive policies and procedures to protect data and privacy while ensuring that participants' data rights and privacy are safeguarded.</p>	Policies are created and documented to protect data, privacy, intellectual property rights, and similar aspects.
<p>4. Strategy for the Data Space</p> <p>Objective</p> <p>Define the way in which the governance authority aims to keep the data up-to-date and relevant.</p>	How does the data space identify the need to change its business model, redesign it, and effectuate these desired changes?	<p>Business Model</p> <p>Insights into the regular monitoring, reviewing, and adaptation of the business model to meet the data space's potential for growth and sustainable expansion.</p>	A process detailing how the business model is reviewed, who is responsible for this, and the metrics and KPIs that determine when and how the business model should be adjusted.
	How will growth ambitions be realized?	<p>Business Model</p> <p>Explains how multi-sidedness an important characteristic of a data space is and discusses how a business model may evolve over time.</p>	A clear decision on the direction in which the data space should grow (i.e. more use cases, service providers, primarily participants) and a process for achieving that growth, including who is responsible.
	How does the data space foster a collaborative culture and manage transparency and efficient communication?	<p>Participation Management</p> <p>Suggests mechanisms for improving participation management through feedback channels, dispute resolution, and fostering a collaborative culture within the data space.</p>	Define what a collaborative culture is for your data space by establishing core values and fully integrating them into your design principles.

6.6.2.3 Functional analysis and data space design

What is the result of the process?

- Translates the functional requirements into a design for the data space, detailing the necessary building blocks, standards, and services.
- The design should include technical and organizational components, as well as agreements about governance and policies.

Who should take action regarding the result?

- The data space authority is responsible for documenting the decisions made, such as those regarding standards, roles, responsibilities, and other specifications, in the rulebook.

What can the actors do with the result?

- Service providers can start building and connecting their services according to the specifications of the data space.
- Participants can start preparing their offerings and their connection to the data space.

Steps	Questions	DSSC Building Block	Outcome
1. Secure Participant Onboarding and Offboarding	What identity verification methods are employed by the data space to ensure secure participant access and interaction within and/or across data spaces?	Identity and Attestation Management Provides an approach for managing identities and attestations while ensuring interoperability, security, and trust based on widely recognised technical standards and regulatory frameworks.	The definition of the digital identity technology and standards that will be used in the data space.
	What kind of identifiers are used in the data space to identify digital entities?	Identity and Attestation Management Prescribes Decentralized Identifiers (DIDs) as a new type of identifier that enables verifiable, decentralized digital identity.	Users are able to create and manage their own digital identities.
	What common standards are used to present, share and verify information about the relevant entities (attestations) in the data space?	Identity and Attestation Management Provides Verifiable Credentials based on the W3C Verifiable Credentials to describe attestations within a data space, serving as the reference standard for digital attestations.	Credentials can be signed with DIDs (question 2) to ensure they can be verified.
	What kind of trust anchors should the data space have to validate and verify the credentials of	Trust Framework Provides an approach for verifying that a participant in a data space adheres to certain rules and common	Trust anchors will validate and verify digital identities and claims (or attestations) made by

	participants?	standards, as outlined in the governance framework regarding participants.	the entities.
	Who are the trust anchors? What type of registry is adequate to store and update the list of trust anchors in data spaces?	Trust Framework Offers the EU/EAA trusted lists of qualified trust service providers (TSPs) that are fully aligned with the eIDAS regulation, based on the data space governance framework, which outlines the requirements, criteria, and regulatory needs.	A list of trust anchors stored in your data space registry (the credential store of the participant agent,
2. Trust among participants	What type of methods and technical enablers can be combined to increase the level of trust among the participants?	Trust Framework Provides an overview of additional levels of assurance and trust conforming to EU regulations.	The use of EU/EAA trusted lists of qualified trust service providers, which are fully aligned with the European Digital Identity Framework Regulation and offer additional levels of trust.
	How can participants of a data space store and manage their Verifiable Credentials to authenticate and verify the information/claims made by other participants?	Identity & attestation management Prescribes the use of a participant agent (credential store) service.	A credential store that allows data space participants to store, manage, and exchange their Verifiable Credentials (VCs) and/or attestations issued by trusted authorities, using authentication protocols like OpenID Connect.
	How does the data space manage access control mechanisms to enforce usage policies across different use cases?	Access control and Usage Policies Enforcement Provides guidance on specifying role-based access controls, permission settings, and usage policies tailored to each use case to regulate data access and operations.	An overview of the roles required to ensure proper data space access management, along with the responsibilities associated with these roles.
	Which common access & usage policies exist in the data space?	Access control and Usage Policies Enforcement Clarifies how to articulate rules regarding content usage.	Verified participants can use the Open Digital Rights Language (ODRL) standard to specify digital policies and

			rules.
<p>3. Agreements on Data Models and Protocols to Exchange Data</p> <p>Objective</p> <p>In this step, the data models and communication protocols are defined.</p>	How will the data space manage semantics for the defined data products?	<p>Data Models</p> <p>Outlines how to semantically describe the data products using data models.</p>	Inventory of necessary standards and guidelines for consistent data interpretation and integration.
	What kind of data models are needed, and can these be reused, or should they be developed?	<p>Data Models</p> <p>Provides an overview of different abstraction levels of data models for semantically annotating the data being shared in the data space and explains how to implement this building block.</p>	Determine if you should reuse current data models or develop new ones, and clearly define the levels of abstraction required to semantically describe your data products.
	What kind of meta-standard will be used to express the data models in the data space?	<p>Data Models</p> <p>offers a list of best practices for metamodels to establish and/or annotate a domain-specific data model.</p>	Align with one or more meta-standards to describe your data models, depending on the necessary levels of abstraction. For instance, RDF or JSON Schema.
	How can we establish an efficient and standardised data exchange among participants in the data space? And what implications does this have for the participants' data models?	<p>Data Exchange</p> <p>Offers guidance on ensuring that data is exchanged according to the specified semantics within the data model.</p>	A list of functional requirements for protocols and interfaces to ensure compatibility and integration with the data models.
	What kind of data exchange protocol will be used?	<p>Data Exchange</p> <p>Elaborates on the use and management of data exchange protocols for actual data exchange, explaining the difference between the control plane and the data plane.</p>	A list of one or more data exchange protocols to be used in the data space, such as OpenAPI Specifications.
	How can we make sure that a data model is used for the actual data exchange?	<p>Data Models</p> <p>The Data Models building block describes how different abstraction levels of data models can be used in actual protocols for data exchange.</p> <p>Data Exchange</p> <p>Offers guidance on</p>	Data exchanged via the data exchange protocol are semantically compliant with the data models.

		choosing suitable exchange protocols for accessing shared data.	
4. Accountability and Control of Data Usage	Which Policy Information Points should be provided on a data space level?	Access and Usage Policies Enforcement Describes how it may sometimes be necessary to provide shared Policy Information Points.	For every offering that should be exchanged automatically, the control plane should be able to create a request to the PEP, which the PEP is able to answer back
	Is there a way to trace the origin and history of data within the data space?	Provenance and Traceability Offers mechanisms for tracking data lineage and ensuring transparency in data transactions.	For each offering, define what type of observability, provenance and traceability is possible and/or required.
	How can a data space participant trace the data of the transactions they are a part of? Can other participants keep/store logs of data sharing that I am a part of?	Provenance and Traceability Explains how a data space could trace data and which tools could be useful for that.	Define what enables provenance and traceability in the data models for each data product, and identify the contractual and legal requirements that specify exactly what must be verified for each data product.
5. Categorisation and Implementation of Services	What is the scope of the data space's catalogue?	Publication and Discovery Explains that in some data spaces, it is sufficient to implement a catalogue merely as a technical index to enable participants to find each other's participant agent services.	A clear set of requirements regarding how participant agent services should communicate with one another or with the catalogue.
	How will the different services be implemented technically?	Value Creation Services Describes services that aim to create value from the data shared in the data space.	Defining how the services in Develop Use Cases and Identify Functional Requirements - Step 4 will be formed technically.
	Which functionalities of the data space could or should be provided by dedicated intermediary service providers?	Intermediaries and Operators Outlines the existence of intermediary service providers that allow participants without their own participant agent to join a data space.	Design the functionalities for each specific service provider and the data space authority.

6.6.2.4 Document data space policies and agreements

What is the result of the process?

- The completion of the development processes (at least the first iteration) by documenting the policies and agreements needed to run the data space.
- Policies, coming from both business and organisational as well as technical building blocks, will populate the rulebook. These policies are meant to govern the internal data space processes.
- Agreements are made with third parties, such as other data spaces, enabling or value-added services, or utilities like water and electricity providers.

When exchanging or buying and selling data, agreements are also made. However, these agreements are usually between data space members (i.e. bilateral) and, therefore, outside of the scope of this development process.

Who should take action regarding the result?

- The data space authority has their rulebook finished and filled in.
- The data space authority has its contractual framework in place.
- The data space participants can provide their offerings.

What can the actors do with the results?

- All participants and stakeholders in the data space can follow and act according to the rules defined when the data space was set up.
- The first iteration of the data space definition is finished once this process is done.

Steps	Questions	DSSC Building Block	Outcome
1. Populate the Rulebook Objective Record all the policies necessary to allow the data space to run as intended.	What are the basic organisational policies that need to be implemented by the governance authority in the rulebook?	Contractual Framework Offers an overview of the different policies that must be implemented by the data space. Pay particular attention to the general terms and conditions.	The fundamental contractual framework should be established. Refer to Figure 1 in the Contractual Framework building block for the structure.
	Which design choices from the Functional Analysis and Data Space Design development process need policies to be included in the rulebook?	In other processes, numerous decisions are made and documented, particularly regarding policies, the use of standards, and software.	For each of the building blocks defined below, the addressed elements are entered into the rulebook.
	Is the data space responsible for the interoperability obligations stipulated in the	Regulatory Compliance Outlines the elements to consider when assessing regulatory compliance.	Review the trigger flowcharts in the building block and develop the necessary

	Data Act, ensuring adherence to standards and interoperability requirements?		policies/documents to adhere to the relevant legislation.
	Do any of the parties involved in the data space function as a data intermediary or collaborate with one?	Regulatory Compliance definitions of different participants in data spaces.	Examine the trigger flowcharts in the building block and develop the necessary policies/documents to adhere to the relevant legislation.
2. Participants Record Their Offering Policies Objective All participants have registered their offerings in the correct manner in the data space, therefore ensuring the offerings can be shared.	To what extent are the offerings of the data space participants registered?	Data Services and Offerings Descriptions Provides ways in which each participant has to define their offerings. Access & Usage Policy Enforcement Provides an overview of the policies required to allow the control plane to approve or deny data requests.	All participants register their offerings according to the agreed-upon manner defined in the catalogue (whether centralised or decentralised).
3. Record Agreements Objective Formalise all the collaborations the data space has entered.	What are the agreements with third parties and/or other data spaces?	Contractual Framework Provides an overview of what a contractual framework looks like and enables the legal implementation of other building blocks.	Specifically, review the data-sharing agreements and any agreements related to enabling services, such as service agreements. Ensure that the agreements in which the data space authority is involved are clear.
	Are there intermediaries or gatekeepers involved in the data transactions of this data space?	Regulatory Compliance Offers several decision trees that provide guidance.	Go through each of the decision trees and address the relevant regulations in the appropriate agreements.

6.6.3 Implementation stage

The stage in the development cycle that starts when a data space initiative has a sufficiently detailed project plan, milestones and resources (funding and other) for developing its governance framework and infrastructure in the context of a data space pilot. It is typical for this stage that the parties involved in the pilot and the value created for each are also clearly identified.

Functional analysis and data space design
 Establish data space agreement and policies

6.6.4 Operational stage

The stage in the development cycle that starts when a data space initiative has a tested implementation of infrastructure(s) and governance framework, and the first use case becomes operational (data flowing between data providers and data recipients and use case providing the intended value).

6.6.5 Scaling stage

The stage in the development cycle that begins when a data space initiative has consistently and organically attracted new participants and adopted new use cases. At this stage, the data space can be realistically expected to be financially and operationally sustainable, responsive to market changes, and grow over time.

6.7 EU Legal Frameworks

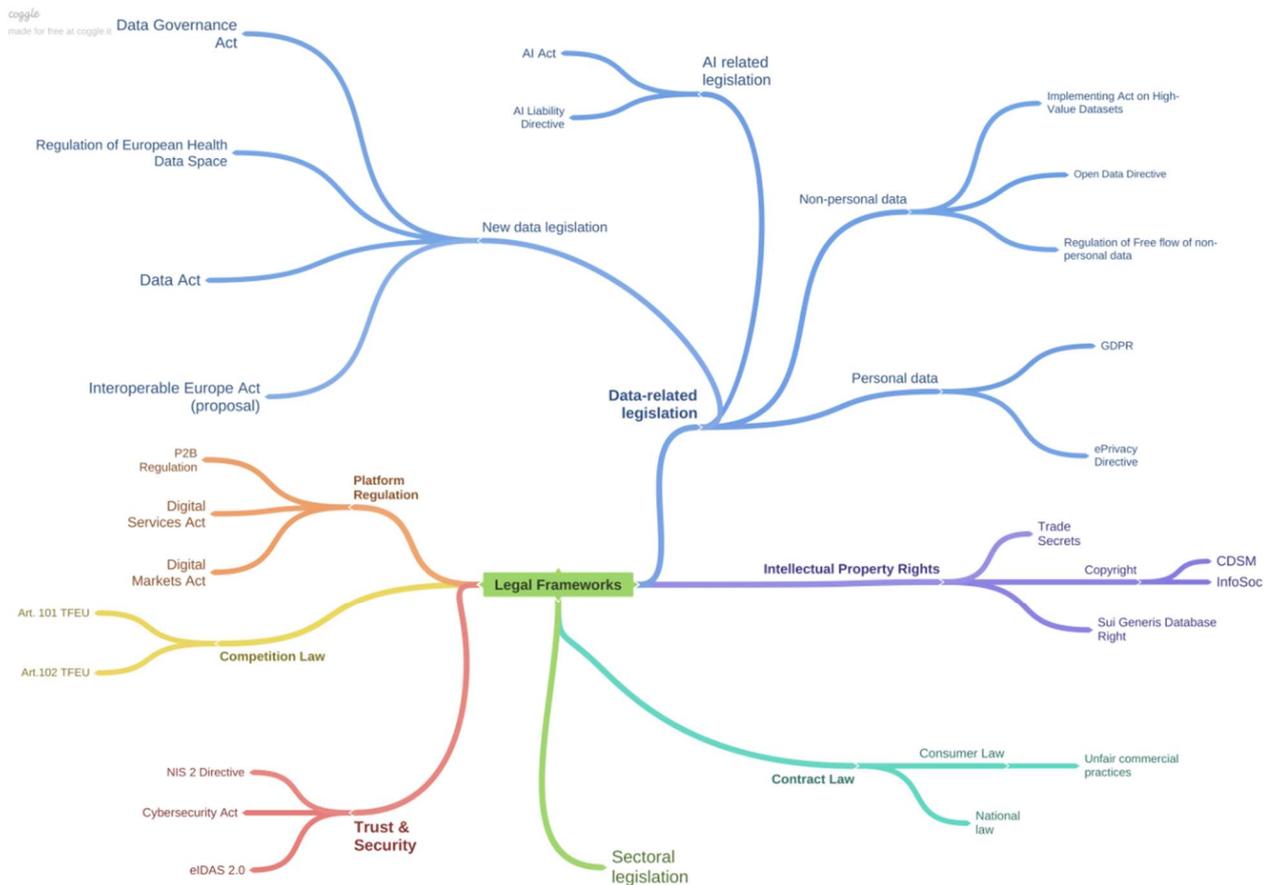


Figure 14. EU legal frameworks

