THE LOGISTICS DATA SHARING INFRASTRUCTURE

TKI DINALOG
Dutch Institute for Advanced Logistics

This white paper originates in the DL4LD research project. It is the result of a collaboration effort between TNO, DL4LD project partners, the University of Twente, with active involvement of TKI Dinalog. Principal researchers have contributed from the DL4LD, the CLiCKS and the ICCOS projects.

- The Dutch NWO Research project '**Data Logistics for Logistics Data**' (**DL4LD,** www.dl4ld.net) is supported by TKI Dinalog [6] and the Dutch Commit-to-Data initiative [7]. It develops a blueprint of a trustworthy data sharing infrastructure for logistics. A focal point is on maintaining sovereignty of the data owner over the access, usage, processing and proliferation of his (potentially sensitive) data.
- The Dutch NWO Research project '**IDS Connector Store and Interoperability Simulator for SMEs**' (**CLiCKS,** https://www.nwo.nl/en/research-and-results/research-projects/i/42/35042.html) aims at lowering the barriers related to data sharing, especially for SMEs, by researching and designing an integrated solution that focuses on two main problems: data interoperability (to share data needed for collaboration between logistics companies) and data sovereignty (to protect proprietary data that has strategic value for logistics companies). The integrated solution is a 'logistics data space', in which the CLiCKS project will develop a 'connector store' that enables semantic interoperability in data sharing between heterogeneous ICT environments and an 'interoperability simulator' that enables assessment of collaboration opportunities and interoperability issues prior implementation.

- The Dutch TKI Dinalog project '**Industry 4.0 driven Supply Chain Coordination for Small- & Medium-sized Enterprises**' (**ICCOS,** https://www.dinalog.nl/project/industry-4-0-driven-supply-chain-coordination-for-small-medium-sized-enterprises-iccos/) aims to improve the competitiveness of the Dutch logistics sector by increasing the adoption and usage of industry 4.0 related technologies in combination with advanced real-time data analytics. The ICCOS project will design a detailed Logistic Data Space Architecture, including guidelines and implementation models, as a foundation to develop Artificial Intelligence Agents to support (semi-)autonomous coordination of supply chains and operational planning, forecasting and replenishment processes.

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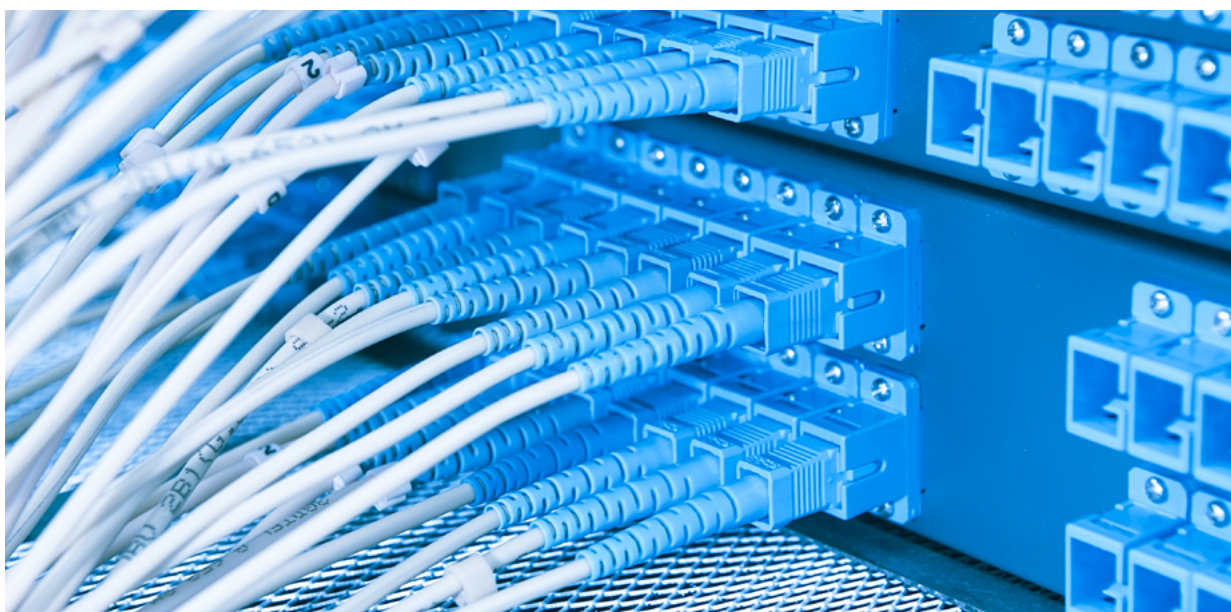**M. Haarman, MSc MBA** NLIP
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1 INTRODUCTION

Digitization of supply and logistics chains offers both opportunities and threats to the logistics sector. Opportunities can be found in a rapidly growing data economy driving new business models and digital ecosystems and platforms. This is accompanied by innovative start-ups developing advanced value propositions, such as Flexport or Uber Freight. At the same time, the digital transformation also poses threats. International trade disputes demonstrate the need for Europe to ensure knowledge-based value creation, in which Europe must be prevented from becoming too dependent on data platforms and technology originating in other parts of the world. In addition, more independence can help to mitigate the vulnerabilities to cyber attacks, data security and loss of control over potentially sensitive data.

1.1 BACKGROUND

According to a Dutch national study on data and digitization in the logistics sector [1], a large majority of companies in the Dutch logistics industry has a wait-and-see attitude when it comes to digitization, despite the importance they attach to it. Limited IT-awareness and savviness, perceived complexity and limited time allocation are the key reasons behind this reluctant attitude on digital innovation. Pressure on margins forces many companies to prioritize operational issues over innovation. Moreover, the current Dutch logistics landscape is highly fragmented: many SMEs operating in different segments and niches with a very heterogeneous technology landscape.

Nevertheless, the potential of digitization in logistics is recognized. As data is increasingly considered a valuable asset in the emerging data economy, the (r)evolution towards a more data driven digital logistics collaboration environment is currently gaining major interest, nationally and internationally, both by policy makers and operational organizations. In the past decade, the Ministries, Topsector Logistics and many stakeholders invested time, money and efforts in various projects to stimulate data sharing as (parts of) the required digitization infrastructure. Nevertheless, additional steps and efforts can be taken, as will be described in this white paper.

1.2 DATA SHARING AND THE TOPSECTOR LOGISTICS' ACTION AGENDA

The Topsector Logistics has appointed 'data driven' as one of its three priority themes for 2020-2023 in its recently published action agenda [2] and implementation program [3], see Figure 1. The action agenda and implementation program provide guidance to knowledge development and innovation initiatives, together with a strategy for the adoption and scaling of new solutions, products and services.

APPLICATION AREAS	CROSS CUTTING THEMES
Cities, Multimodal Corridors and Hubs, Supply Chains	
KNOWLEDGE DEVELOPMENT, TOOL DEVELOPMENT AND IMPLEMENTATION for a sustainable, safe an competitive logistics sector	Human capital Internationalisation Legislation Innovation monitoring Strategic projects
PRIORITY THEMES Sustainable logistics, Data Driven Logistics, Supply Chain Coordination	

Figure 1. Scope of the Topsector Logistics' action agenda: application areas, priority themes and cross cutting themes.

The figure depicts how the Topsector Logistics' action agenda is organized along the axes of application areas (i.e. cities, multimodal corridors and hubs, and supply chains) and priority themes (i.e. sustainable logistics, data driven logistics and supply chain coordination). The priority theme 'data driven logistics' crosses the three application areas. As the implementation program [3] describes, it addresses both the importance of data driven decision making as prerequisite for a successful transition towards an emission free and competitive logistics system, referred to as 'advanced data use' and the role of an adequate '*data sharing infrastructure*'. This white paper focuses on the latter.

1.3 SCOPE: BASIC LOGISTICS DATA SHARING INFRASTRUCTURE

Sharing of data has many facets. These range from the secure transport of data over the Internet to (harmonization) of processes and services at the application level. Therefore, the topic of the data sharing infrastructure as addressed in this white paper is scoped to the basic infrastructure for responsible and controlled data sharing. This is also referred to as a basic data infrastructure (BDI), which is currently recognized as a key enabler for capitalizing the potential benefits of the data economy.

From the perspective of data sharing organizations, the European values on data sovereignty (i.e. the data owner staying in control over how his data is accessed, used and proliferated), ethics, legality, privacy and security are necessary preconditions for sharing their potentially sensitive data and are to be supported by the basic data sharing infrastructure. Therefore, the scope of the data sharing infrastructure as addressed in this white paper is on enabling data owners to share their potentially sensitive data whilst taking into account these values of responsible and controlled data sharing.

The data sharing infrastructure allows data owners to control the sharing of data with either other organizations bilaterally or through cross-organization (e.g. supply chain) business processes or data handling solutions. As such, it integrates with and adds value to a broad set of complementary data handling concepts, solutions and collaboration models, e.g. based on distributed ledger (blockchain), federated learning and multi-party computation technologies [4].

Furthermore, it is to be noted that data processing functions that are related to the actual sharing of data (e.g. for semantic conversions between data formats, management of the data quality and pseudonymization or anonymization) are to be supported and enabled by the data sharing infrastructure, although they are not part of the infrastructure itself.

1.4 GOAL

The goal of this white paper is to provide guidance to the Topsector Logistics implementation program on the data sharing infrastructure as part of the priority theme 'data driven logistics', by:
- describing the current developments in data sharing policy making and data sharing architectures,
- identifying a structure and portfolio of key data sharing functions to be realized as generic, re-usable, services (building blocks), based on a representative set of use cases for the three application areas as depicted in Figure 1, and
- providing a development roadmap as input for the implementation program.

This white paper may help logistics policy makers in defining innovation activities, the logistics sector in its quest to stay competitive and become more sustainable and logistics organizations to position themselves in the digital transformation towards the data driven ecosystem.

The topic of data sharing infrastructures is rather technical. Its success heavily relies on the adoption as part of the logistic sectors digitization strategy. Although beyond the scope of this white paper, it is briefly addressed in section 4.5.
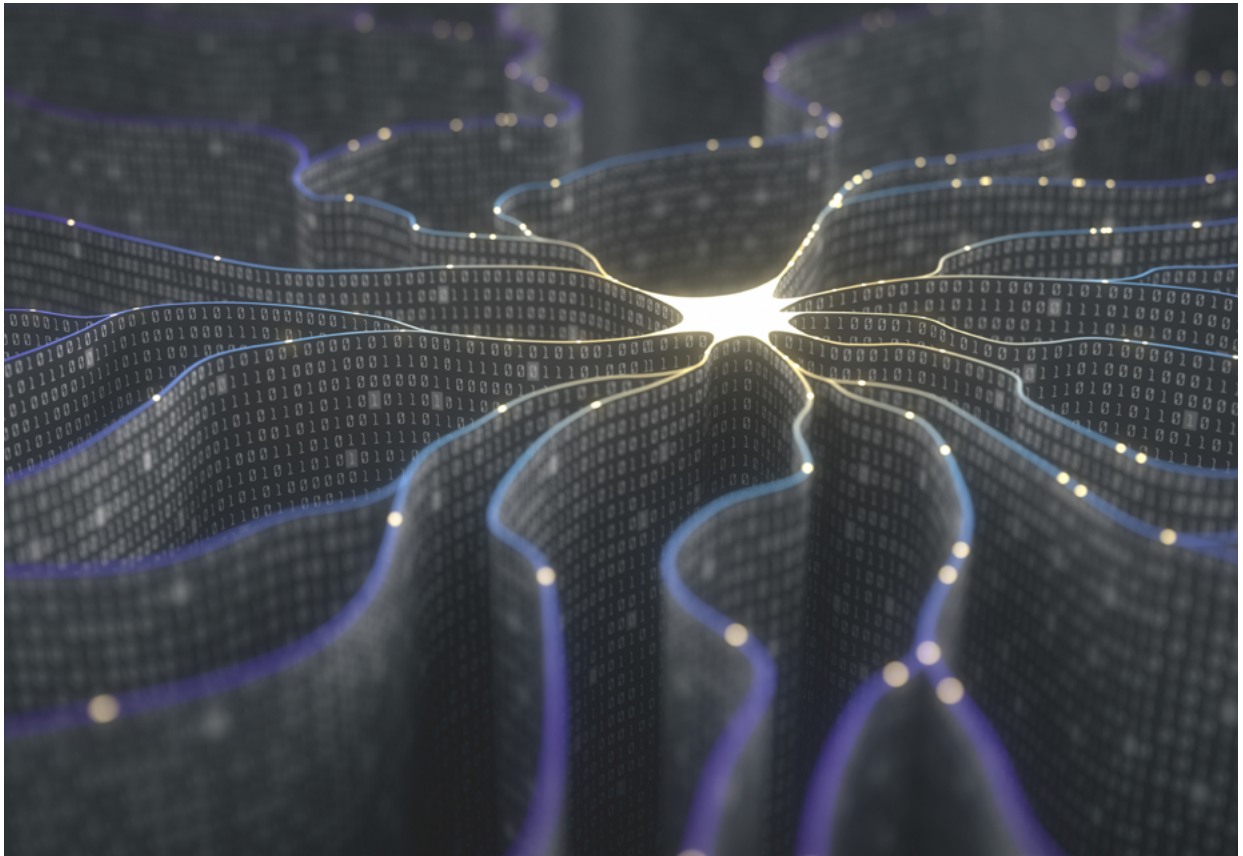
1.5 STRUCTURE

The subsequent chapters build up the storyline why the logistics sector needs an adequate enabling data sharing infrastructure and how to realize it. In chapter 2, the need for data sharing in logistics is elaborated in the context of the major transformation challenges in digitization and sustainability. Subsequently, chapter 3 describes the relevant data sharing policy making and development initiatives, both nationally and internationally. Chapter 4 gives an overview of data sharing requirements, within logistics and in other sectors, together with an evolution path for the logistics data sharing infrastructure. It results in a development roadmap on technology, organization and ecosystem. The final chapter 5 presents the main conclusions. In addition, the paper has an appendix in which a set of representative use cases is elaborated for the three application areas as identified in Topsector Logistics'

action agenda [2]. Jointly, these illustrate the needs for a logistics data sharing infrastructure.

1.6 CONTEXT

This white paper originates in the Dutch NWO Research project 'Data Logistics for Logistics Data' (DL4LD [5]), which is supported by TKI Dinalog (the Dutch Institute for Advanced Logistics [6]) and the Dutch Commit-to-Data initiative (Commit2Data [7]). The project is led by TNO. It addresses the development of a blueprint of a trustworthy data sharing infrastructure for logistics. A focal point is on maintaining sovereignty by the data owner over their data. In collaboration between TNO, DL4LD project partners and the University of Twente and with active involvement of TKI Dinalog, this white paper has been developed with a broader vision on data sharing for logistics.

2 THE NEED FOR DATA SHARING IN LOGISTICS

**Data sharing in logistics has been an innovation topic since the beginning of this century. The Van Laarhoven Committee [8] already addressed the importance of information flows throughout the supply chain and integration of physical and financial flows for realizing a competitive and sustainable logistics sector. This resulted in the 'Neutral Logistics Information Platform (NLIP)' program [9]. The NLIP program highlighted the complexity and showed that convergence of all relevant stakeholders towards a common goal is not a straightforward process. Nevertheless, despite conflicting interests, lack of urgency, lack of trust and lack of clarity on the value case, the first steps in creating building blocks for a digital infrastructure were successfully initiated.
However, where a decade ago the need and urgency was not strong enough and the solution too complex, now is the moment to accelerate the agenda for data sharing in logistics in the context of the major digital transformation challenges for competitiveness and sustainability. The following sections in this chapter describe the company data valorization route and the data sharing ecosystem route as subsequent evolutionary steps towards fulfilling the need for data sharing in logistics, together with a description of the status quo.**

2.1 THE COMPANY DATA VALORIZATION ROUTE: OPTIMIZING INTERNAL AND SUPPLY CHAIN OPERATIONS

Many logistics companies have made steps in digitizing their internal processes. In doing so, the larger companies request their suppliers and service providers to exchange data with them in a digital way in order to support their own internal process optimization, e.g. for planning data. Each partner uses its own interface specifications. The result is a multitude of different interfaces, confronting the sector as a whole with inter-operability issues.

Though company data is stored in company-wide systems, the use is often restricted to a particular department: procurement uses purchase order information, finance uses invoice data, marketing uses customer data, operations uses transport order data, customs compliance uses declaration data. According to a Dutch survey [1], in 50% of the companies, these different systems are hardly or not at all interoperable.

In recent years, many companies have expressed the desire to create more value out of the compa-

ny data, for instance by applying more advanced data analytics methods to better anticipate or forecast. But in reality, they find it already challenging to combine and integrate data from different internal systems, let alone the integration of data throughout their supply chain.

In many collaborative chain initiatives, valorizing the merits of chain-wide data integration proved requiring more than just mitigating the reluctance to share commercially sensitive data and solving technical data interoperability issues. Process optimization would often require other incentive systems, gain sharing arrangements, adjustments in contracts, more transparency in KPI measurements, and adjustment of standard operating procedures within the company. The friction costs of all these technical and organizational adjustments was simply too high to justify a doubtful business case with many uncertainties around the probability that projected benefits would actually materialize. Apparently, suboptimal organization is an accepted reality across supply chains.

2.2 THE DATA SHARING ECOSYSTEM ROUTE: TOWARDS LOGISTICS COMPETITIVENESS AND SUSTAINABILITY

The world is changing. The emerging data economy requires companies to define their strategy and pathway towards becoming data driven. Within the current paradigm, logistics companies make rather slow progress in sharing data and seem to accept existing supply chain inefficiencies to a certain extent. Disruptive events such as COVID-19 have stressed the importance of supply chain resilience and the need for supply chain visibility.

But in order to really make substantial steps, sharing data along and beyond the supply chains becomes a necessity to stay competitive and/or become more sustainable. Hence, an addition (or alternative) to the company data valorization route is emerging: the route via ecosystem-wide solutions . Data sharing is enabling this digital transformation. Here we see that communities with contextual similarities aim to set standards. Obvious examples include data exchange to support port or airport related processes (Port Community Systems). And industries aim to come up with industry-specific standards to support data sharing, such as the Digital Container Shipping Association (DCSA) in containerized transport. Two main digital transformation drivers for the data sharing ecosystem route are:

- **Data sharing for staying competitive**
  Documents become digitized, as is currently happening in logistics, and repetitive tasks are automated. Internet of things enters into logistics: IoT sensors make logistics assets becoming smart and enabling real-time visibility. Processes are becoming autonomous, also logistics operations such as order picking, transportation, or transshipment in ports. Furthermore, rapidly switches preferred suppliers ever more frequently occur. Data platform organizations such as Uber Freight, Amazon, and Flexport enter the logistics market with data driven service propositions, such as digital booking and forwarding. These developments are already disrupting some logistics markets, such as freight forwarding or ecommerce fulfilment. But this is just the beginning.

  Data is the fuel and data sharing the motor to develop competitive logistics business models and strategies. Data savvy companies have the

capabilities to apply analytics to the data and generate valuable insights from these data elements. These organizations will actively explore new sources of data (e.g. sensor data) to support their business processes and provide valuable insights and predict the future logistics state. These developments are already disrupting some logistics markets, such as freight forwarding or ecommerce fulfilment. But this is just the beginning.

Moreover, the lack of supply chain visibility becomes a more imminent challenge. Many companies do not know where goods are, how many there are available, when stock will be replenished, and do not known the actual demand. This lack of visibility leads to higher stocks and higher logistics costs, the so-called bull-whip effect. Data sharing for stock in warehouses, with suppliers and their suppliers, and stock in pipeline is required to meet actual demands. Analysis of customer orders and even their orders would greatly improve stock positions and deliveries.

- **Data sharing for sustainable logistics**
  Sustainability is the second transformation that increases the sense of urgency for sharing data in logistics. Inefficiencies in logistics chains and networks cannot longer be accepted. Sustainability objectives will drive the need to get rid of supply chain inefficiencies. It cannot and will not be accepted any longer to just optimize internal business processes. Pressure from end users and governments will drive us further towards chain optimization.

  Data sharing is not just a prerequisite to get rid of those supply chain inefficiencies, but also to ensure compliance with the legal logistics framework. Unnecessary long lead times and waiting times become unacceptable, and transparency will highlight where these inefficiencies appear. Advanced data analytics, combining planning data from the different supply chain actors with sensor data on the cargo status and conditions and other contextual external data result in synchronized supply chains, elimination of waste and improved logistics asset utilization.

In these processes of digitization towards the emerging data economy, data is becoming a valuable asset. It requires a future-proof data sharing infrastructure for logistics: an open environment that facilitates safe, efficient and automated data sharing that supports the organization and execution of logistics processes in an efficient, reliable, flexible and sustainable way. In this way, the Dutch international leading position in logistics can be strengthened and logistics may be decarbonized.

2.3 DATA SHARING FOR THE DUTCH LOGISTICS SECTOR: STATUS QUO

So, what is the status of data sharing in Dutch logistics? Digitization has boosted internal optimization, though with a different adoption pace amongst the logistics actors. Advanced data analytics techniques are slowly being adopted, mainly by the larger companies with a specialized workforce [1]. Nevertheless, data sharing for logistics is still in its infancy, apart from some exceptional initiatives where collaboration is mastered by actors with the market power to steer their partners in their desired direction. Examples are for instance in food retail and logistics, driving adoption of data sharing standards, barcoding, master

data management for its logistics processes and a semantic interoperability standard.

The Topsector Logistics, Dutch companies, governmental bodies and knowledge institutes have cooperated actively in various national and European innovation projects on logistics data sharing. These projects addressed aspects like data interoperability, semantic models, event driven architectures, authentication, but also architectures for data driven service models. They helped in implementing Dutch government policies (e.g. in customs and maritime transport), and gave guidance/direction to national initiatives such as Single Window Trade and Transport. These projects showed that data sharing needs are partly domain-, industry-, and context-specific and data sharing solutions have often been enforced, either by regulation or by powerful value chain parties. A major effort was spent on 'getting quality data', and valorizing the shared data position.

Data integration appeared to be hard, indicating the need for an improved data sharing infrastructure. As such, important initiatives are the Dutch Association of Logistics and Transport IT

suppliers (DALTI) [10] and the Stichting Uniforme Transport Code (SUTC) [11]. DALTI brings together IT solutions providers in logistics to implement standards. SUTC stimulates a uniform and unambiguous way for sharing data between logistics systems by promoting standards to improve logistics efficiency, e.g.:

- **iSHARE**, a Dutch data sharing agreement framework for the logistics sector with a uniform series of agreements for identification, authentication and authorization, developed by NLIP.
- **Open Trip Model (OTM)**, an open source data model ('dictionary') and set of Application Programming Interfaces (APIs) for sharing real-time logistics trip data.
- **eCMR platforms**, to accelerate digital exchange of the CMR (Convention Relative au Contrat de Transport International de Marchandises par Route) consignment note, which must be used for an international transport order.
- **Paperless Transport**, regulating the acceptance of data by authorities based on the electronic Freight Transport Regulation (to be fully implemented by 2025), addressing digitization in the context of various other regulations like dangerous – and waste cargo transport and cabotage.
- **Elektronische Begeleidingsbrief Afval (EBA)**, an open standard for exchanging information that is included in the legally required cover letter for transporting waste.

The overview can be complemented with specific data sharing initiatives in inland shipping and rail transport.

2.4 DATA SHARING TO ACCELERATE THE DIGITAL TRANSFORMATION

As described, the world is changing rapidly and the logistics sector has to accelerate its digital transformation. Progress in internal process optimization, major challenges in sustainability and the emerging data-economy are increasing the urgency. Meanwhile, technological progress in ICT brings mature and adequate data sharing solutions closer to reality. The data economy shows many successful examples of data driven value propositions and scalable data driven service models. Logistics policy makers and organizations need to position themselves in this digital transformation to stay competitive.

Logistics companies are becoming ever more convinced that data represents a valuable asset. However, data is to a large extent still locked into stovepipe legacy systems. The lack of an adequate data sharing infrastructure, giving the data owners control and sovereignty over their sensitive data, results in reluctance to share this data. As progress is currently still relatively low, strategies and investments are needed to 'open up' these systems and make data available. To further help all stakeholders in the logistics ecosystem in their collaborative digital transformation, an overarching data sharing framework is needed that caters in a flexible and sustainable way for a large variety of data sharing and data processing requirements. This will be addressed in the following chapter.

3 DATA SHARING POLICY MAKING AND DEVELOPMENT INITIATIVES

Data has value and stakeholders have different (potentially conflicting) goals and needs. Some data is freely available, other data is available under particular conditions. Concerns on misuse of data due to a perceived lack of control (data sovereignty, trust, liability, and security) hinder large-scale data sharing. There may be costs involved in making data accessible. In addition, regulatory restrictions may apply on data sharing, such as the General Data Protection Regulation (GDPR).

These concerns are barriers for data sharing, despite the potential benefits of data sharing on a larger scale. This not only applies to logistics. A common need for data sharing and digitization is felt across organizations in various sectors of society. This has led to a multitude of (inter-)national activities in data sharing policy making and development initiatives. The subsequent sections in this chapter give an overview from the EU and the Dutch perspective, respectively.

3.1 EU INITIATIVES ON (LOGISTICS) DATA SHARING

The importance of data sharing is well recognized by the EU. Various major activities can be mentioned.

The EC policy agenda covers both public and private sector developments for the creation of the EU Digital Single Market [12] with a number of initiatives. One of the initiatives is to create the European Data Space in the context of the European Data Strategy [13] [14]. The objective is not only to digitize data sharing between stakeholders in various industries and with authorities (private and public domain), but also to stimulate innovation and create a new market for data analytics and AI in Europe [15] [16] [17]. Additionally, in response to these communications by the European Commission the Big Data Value Association (BDVA) has released a white paper [18] identifying the key technical challenges to realize a cross-border, cross-sectoral sharing data space to process 'mixed' proprietary, personal and open public data.

The EC Directorate General for Communications Networks, Content and Technology (DG CNECT) has taken the initiative to create a public pan-European data sharing infrastructure based on ledger technology (European Blockchain Services Infrastructure - EBSI [19]). The initiative already provides horizontal functions which are applicable for all types of data sharing (like identity management). It will be extend-ed to support verticals like provenance of materials, goods, and food. Whereas the main focus of EBSI is the public sector, it also intends to create applications for European consumers like a Digital Passport for consumer goods. These need to contain details of the provenance of goods and their parts. It would cover all types of consumer goods, including food and agricultural products.

The DTLF (Digital Transport and Logistics Forum [20]) is the EC Directorate-General for Mobility and Transport (DG Move) initiative in the context of this EC policy with the objective to create a European Data Space for Supply and Logistics [21]. This data space should utilize various solutions of different providers, each with their own business model and governance structure, where these solutions will have to be interoperable. The latter is required for allowing organizations, authorities and enterprises, to connect once to a solution of choice of a provider and share or access data with all relevant partners according the principles of data sovereignty.

To achieve this objective, DTLF not only has its internal structure by which members contribute to the solution, but also initiated the Connecting Europe Facility (CEF) FEDeRATED Action [22] and the CEF FENIX Action [23]. Where FEDeRATED takes a top down approach driven by authorities and embedded

in their national digitization strategies, FENIX is driven by industry taking a bottom up approach by creating platform interoperability for a large number of use cases. Both FEDeRATED and FENIX are constantly aligning their efforts to provide coordinated input to the DTLF.

Within the EU, the European Technology Platform 'Alliance for Logistics Innovation through Collaboration in Europe' (ETP ALICE [24]) provides industry input to the EU research agenda for sustainable supply and logistics. Its Systems & Technologies for Interconnected Logistics research and innovation roadmap identifies the need for new business models and data governance approaches with collaboration to enable trust and data sovereignty [25].

In addition to these policy initiatives, developments in the adjacent area of cloud strategies are relevant. For example, the German and French government launched GAIA-X at the end of 2019 [26], which provides a European cloud strategy as a response to the manner in which major US and Asian (often Chinese) platforms are developed and operated. Access to data and interoperability between the cloud environments of different providers play a crucial role in the GAIA-X initiative. Its approach is based on European values where privacy-by-design and data sovereignty are basic principles. GAIA-X is adopted by EC DG CNECT and thus part of the European Data Space policy initiative.

3.2 DUTCH INITIATIVES ON (LOGISTICS) DATA SHARING

At a generic level, the Dutch Ministry of Economic Affairs and Climate has published various policy documents on the topic of sharing data within and between economic sectors [27] [28] [29], outlining the economic value of data sharing and the importance of an adequate data sharing environment as a key enabler.

More specific for the logistics sector, the Dutch Ministry of Infrastructure and Water published the Digital Transport Strategy (DTS) [30]. DTS has pillars like paperless transport and electronic Maritime Single Window (eMSW), but also includes the creation of a Basic Data sharing Infrastructure (BDI). The first step taken in collaboration with Dutch Customs Administration is the creation of a Public Private Partnership for business to government (B2G) and business to business (B2B) data sharing in communities like the Rotterdam port and Schiphol Airport. As part of the DTS, initiatives are taken by the

Ministry to install data sharing communities for the various modalities like rail, road, and inland waterways. Furthermore, the DTS is part of the CEF FEDeRATED Action as described in the previous section. The objective is to create a master plan [31] for data sharing in supply and logistics, as input to the DTLF. FEDeRATED will launch over 20 Living Labs in various EU Member States. As part of the DTS, the Ministry launches the following Living Labs in FEDeRATED within the Netherlands:

- **Data Exchange Facility Logistics (DEFlog)** [32]. This public-private digitization initiative is aimed at sharing data between organizations and the government and vice versa, although sharing of data between organizations is also foreseen. Portbase, the solution provider of the community system of the ports of Amsterdam and Rotterdam develops the initial version. In the Amsterdam region, also Schiphol and the Greenport communities are involved. Data sovereignty and controlled access and usage are elements of the infrastructure. DEFlog will build upon existing standards, tools and agreement frameworks as promoted by the SUTC [11].

- **Medical Supply Chain (MEDSUP).** The objective is to improve supply chain visibility and trust in medical supplies from their source, manufacturers, to their final destination. Suppliers, certification authorities, wholesalers, hospitals, importers, Logistics Service Providers, etc. will be included to fully cover medical supplies and their distribution.

- **Benelux electronic Freight Transport Information (eFTI)**. The objective is to develop solutions based on authority requirements for the implementation of the eFTI Regulation [33]. The Netherlands will initiate the development and provide input to the Benelux Living Lab. Authorities, so-called eFTI platform providers (see before), and Logistics Service Providers will be involved in the Living Lab. The Living Lab will provide input to the implementation of the eFTI Regulation for paperless transport.

4 A DATA SHARING INFRASTRUCTURE FOR LOGISTICS

There is a large diversity in data sharing collaborations in logistics, leading to a variety of expectations on an enabling data sharing infrastructure. Not all usage patterns and applications for a data sharing infrastructure can currently be foreseen. Vice versa, an adequate data sharing infrastructure may lead to new applications and business models which are currently not (yet) envisaged.

Thus, flexibility is important for a logistics data sharing infrastructure. This chapter describes how to meet this challenge. The subsequent sections address the characteristics for logistics data sharing, the approaches for realizing a logistics data sharing infrastructure, including a broader perspective on the operability challenges when connecting a logistics data sharing infrastructure with other data sharing initiatives, and the way forward in the form of a development roadmap.

4.1 CHARACTERISTICS FOR LOGISTICS DATA SHARING

Categorizing the (types of) data to be shared forms the basis of the architecture for the logistics data sharing infrastructure. The paragraphs in this section describe these characteristics along two axes: the axis of a typology for logistics data sharing and the axis of the application areas in the Topsector Logistics' action agenda. In combination, this leads to a 'matrix' of illustrative and representative use cases for logistics data sharing.

4.1.1 Data sharing typology

Based on experience in data sharing initiatives and projects within logistics and various other sectors, this section introduces a data sharing typology distinguishing three types:

- **Sharing of transaction data for operations optimization**
  Changing market dynamics and the increasing need for digital connectivity force organizations to shift from optimizing internal business processes into more collaborative business processes with optimization across supply chains and business ecosystems [34]. A shift from a competitive strategy to a more collaborative strategy is enabled by sharing transaction data for optimization of supply chain operations processes. However, the potential benefits lead to a dichotomy as organizations

are becoming ever more aware that their operations data is a sensitive and valuable asset and should be managed and controlled as such [35].

The characteristics for this type of data sharing are: One-time sharing of data with a strong demand for data sovereignty measures to prevent misuse. Peer-to-peer data sharing is preferred over central data lakes to provide data owners control over the sharing of their (potentially sensitive) data.

- **Sharing of (big) data for data analytics**
  Data analytics (based on artificial intelligence and machine learning technologies) can resolve inefficiencies in business processes and indicate how more integrated and customer-centric business and revenue models may be created. More or less every industrial sector is busy with a similar refinement of the existing processes [36]. Data analytics on available data sets may also be used by completely new entrants in providing innovative services and solutions to the market. For mobility and transport, the Topsector Logistics has recently released a white paper on the possibilities for data analytics based on artificial intelligence [37].

The characteristics for this type of data sharing are [4]: Multiple data sources are shared and should be available for a longer period of time to be used by multiple data analytics applications. This may include data from potential competitors, requiring data sovereignty measures and policies for keeping the data owner in control over his data. A strong demand for data privacy protection measures exists in case privacy sensitive data is involved, or in case the data analytics process may derive privacy sensitive information by combining and analyzing data from multiple sources.

To meet the complex challenges on data sensitivity and privacy, new collaboration models may be considered [4] [38]. These can provide options for either the data analytics algorithms to be executed in the security domain of the data source (such that sensitive data does not leave the data owner's domain, i.e. bring 'analysis-to-data') or for the data to be processed in the security domain of the analytics algorithm provider (such that the sensitive algorithm is not shared with the data owner's, i.e. bring 'data-to-analysis').

- **Sharing of supply chain data for real-time visibility**
  Real-time visibility solutions provide shipment visibility, e.g. truck visibility for road haulage. These solutions may also provide real-time tracking of goods, ETA calculation, monitoring of essential transportation conditions (e.g. for perishable goods), last mile routing and generate exceptions in case of late arrival. Large logistics and transportation companies may have their own private and globally working systems in place. But there is a world of smaller scale transport companies that cannot afford a private solution and may be in need of a service that is provided by a third party. Many benefits are to be gained with real-time visibility [39]. According to Descartes [40], there are 5 areas where real-time visibility creates value: deliver superior customer service, reduce labor costs, cut penalties and charge-backs, lower detention fees, improve dock and receiving operations.

The characteristics for this type of data sharing are: One-time sharing of the data. Proliferation of data along the stakeholders in the supply chain. Real-time availability of data.

The data sharing typology based on these three types of logistics data sharing patterns provides a

sound initial foundation to base the architecture of a logistics data sharing infrastructure upon. When deemed necessary, the typology may be extended in the future. It is expected that this will not essentially alter the architectural approach.

4.1.2 Application areas
The transformation towards a digital and sustainable society demands the improved utilization and sharing of digital data. Such a data-driven approach applies to the three key application areas identified in the Topsector Logistics action agenda [2] as depicted in Figure 1: cities, multimodal hubs & corridors, and supply chains:

- **Data driven urban logistics (cities)**
  City logistics is concerned with freight distribution taking place in urban areas as well as the strategies that can improve its overall efficiency while mitigating externalities such as congestion and emissions. It includes the provisioning of services contributing to efficiently managing the movements of goods in cities and providing innovative responses to customer demands and needs from a diversity of stakeholders, such as shop owners, citizens, and commuters.

  Ecommerce has tremendously changed the retail landscape and delivery patterns. Construction works in dense inner-city areas demand a lot from logistics to facilitate construction, avoid nuisance and perform in a sustainable way. Moreover, sustainable city policies result in zero emission zones, access restrictions, and restrictive parking policies. At the same time, smart cities allow us to sense what is going on in cities: mobility patterns, access control, density peaks, local emission levels, social consumer behavior, customer return volumes, just to mention a small subset of what is to be captured and/or measured in cities.

  Data driven logistics will use this urban data space full of sensor data to develop innovative urban logistics solutions that cope with the demanding requirements of all these stakeholders. Think of city hubs, equipped with the latest 'anticipatory logistics' functionality (control tower 4.0) for consolidated inbound and outbound flows to and from construction sites, consolidation concepts for home deliveries, easy-to-use public and private charging infrastructures, peak-shaving or sustainability-driven pricing/ ordering mechanisms on electronic marketplaces. Smart consol-

idation and collection concepts for sustainable delivery bikes, dynamic access control driven by local emission exposure levels.

These innovative sustainable urban logistics solutions require data savvy entrepreneurs and service providers that apply latest technologies and develop sustainable, innovative and customer centric solutions, supported by data analytics capabilities. Both public and private data can be combined for the benefit of sustainable urban logistics. A data sharing infrastructure is needed that collects and shares all relevant contextual data and shares relevant business process data to develop innovative and (privacy) compliant solutions. Local governments may provide the public data sharing infrastructure to ease access to public data sources, and stimulate digital processes for business-to-government (B2G) information exchange.

- **Data driven multimodal corridors & hubs**
This priority application domain focuses on strengthening sustainable business models and entrepreneurship in multimodal transport, and stimulating modal shift. Specific attention is given to incentivization of sustainable behavior between the economic actors in these multimodal networks. Today, cost is the most dominant factor in operation decision making. A mental shift is required to consider other factors and alternative modes of transport. Logistics is a facilitator for trade and the willingness to pay for the right logistics service should be more leading in the whole organization and service offering of multimodal transport. It needs feeding decision support systems recognizing this broader set of objectives with the right input data, provided by different actors and entities.

Today's organization of hinterland transport of maritime containers with the contractual relationships and arrangements between shippers, freight forwarders, (inland) terminal operators, and ocean carriers are focused on asset utilization and minimizing costs. As a consequence, there is room for improvement of service quality, reliability and flexibility of non-road transport solutions. Cost is King and the contracts, Service Level Agreements (SLAs) and incentive systems do not allow for much service differentiation. However, service differentiation is the way forward to integrate sustainability into logistics solutions. Supply chain dynamics require a more balanced

weighted average of different logistics requirements: cost efficiency, service quality, robustness and of course sustainability. Strong fluctuations in demand can change a standard shipment into a priority shipment. The same applies for instance to a container shipment with perishables that ripen faster than anticipated.

Service differentiation and flexible allocation of multimodal capacities could simultaneously contribute to sustainability, efficiency, agility and resilience. In order to realize dynamic logistics service offering in multimodal transport, there is a need for an IT infrastructure with equal access opportunities, secure handling and enable sovereignty that offers real-time and full end-to-end visibility, a logistics service infrastructure able to provide end-to-end visibility and service differentiation, and a contractual environment that facilitates logistics ecosystems with dynamic contracts.

As stated in the latest 'Ontwerp Havennota 2020-2030' [41], mainport policy has broadened its scope. This offers the Topsector Logistics clear guidance to integrate regional hub platforms (e.g. Greenports and inland hubs) into a federated network of platforms in order to realize the innovative sustainable multimodal business models.

- **Data driven supply chains**
The supply chain application domain focuses on two pillars; the transition towards sustainable supply chain networks and the digital transformation towards supply chains of the future.

The first is about effective collaboration and gain sharing models and mechanisms and corresponding service concepts, with strong synergies to the data needs for agile multimodal transportation.

The second is about applying potentially disruptive digital innovations such as AI, blockchain, IoT, digital twinning, digital platforms and robotics and the transition towards self-organizing logistics service models. Artificial Intelligence offers opportunities for logistics to develop innovative solutions that simultaneously strengthens our economic position as well as the socio-economic challenges related to the movement of (passengers and) freight. Promising applications include autonomous transport means, predictive maintenance and self-organizing logistics. IoT technology not only allows for asset and shipment

tracking, but also allows for monitoring contextually relevant cargo conditions. This is for instance relevant in perishable supply chains, where real-time visibility and anticipative supply chain approaches can be applied to safeguard high product quality and availability and avoid waste. Digital twins integrate IoT, artificial intelligence, machine learning and software analytics with spatial network graphs to create living digital simulation models that update and change as their physical counterparts change. Digital twins are being used to optimize the operation and maintenance of physical assets, systems, manufacturing and logistic processes. DHL identifies promising applications of robotics in logistics, particularly in order picking, packing, home delivery and unloading of trucks and containers. All these innovative and potentially disruptive digital applications require data infrastructures with advanced data processing and enrichment functionalities, as described in section 4.2.3.

It is obvious that all require a data sharing infrastructure supporting such innovative data driven supply chains and enable the Netherlands to become a supply chain coordinator and create economic added value by offering these services.

But the same applies to the collaborative sustainable supply chain agenda. Collaboration is not an objective but a means to simultaneously create sustainable and competitive supply chain solutions. And this can only be realized if supported by an effective an efficient data sharing infrastructure.

4.1.3 Logistic data sharing use cases

Table 1 provides a set of representative and illustrative logistics data sharing use cases, organized along the axes of the high-level typology for logistics data sharing and the three Topsector application areas as described in the previous paragraphs.

The illustrative and representative use cases lead to a diversity in challenges and data sharing functions that will be needed from a logistics data sharing infrastructure. Therefore, each of the use cases in the table is further elaborated in the appendix.

In addition, new use cases may arise which are currently not (yet) envisaged. For instance, the IDSA recently released a white paper together with Fraunhofer IML on the challenges and potential of a logistics data space with an additional set of use cases [42].

		Application Area		
		Cities	**Multimodal corridors and hubs**	**Supply chains**
Type of data sharing	**Transaction data for operations optimization**	**Construction logistics** Optimize supplies to construction sites in narrow-space (inner) cities, minimize vehicle movements and prevent congestion.	**Continental groupage** Improve transport efficiency by aggregation of small(er) shipments for the same corridor/ region.	**Asset management of airplane engines** Share operational flight data from the engines to multiple stakeholders (airline, engine builders, airplane builders, …)
	(Big) data for data analytics	**Smart city logistics** Efficiently manage movements of goods and minimize congestion for replenishing inner city shopping areas with many shops, suppliers and logistics service providers.	**Synchromodal transport planning and operation** Simultaneously offering multiple inland waterway transport, rail and road services along a corridor, optimize multimodal capacity, stimulate mode-neutral bookings and utilize the most suitable transport mode.	**Health & utility monitoring (HUMS) of expensive equipment** Predictive maintenance for expensive machinery, e.g. an advanced naval radar system. Such systems generate sensitive data on the health status and operational performance with a single supplier.
	Supply chain data for real-time visibility data	**Consumer delivery track & trace** Provide consumers real-time insight into the location and delivery of their goods using itinerary information.	**International ecommerce fulfilment** Aligned data sharing between partners in a distributed fulfillment chain, e.g. for producing, picking, packing, distribution and delivery.	**Quality controlled logistics of high-value or perishable goods** Real-time monitor (transport) conditions to prevent that goods are at risk.

Table 1. Logistics data sharing use cases for the various types of data and the application areas.

4.2 DEVELOPING A LOGISTICS DATA SHARING INFRASTRUCTURE

As part of a studies on a generic agreement framework as basis for the digital economy by the Dutch Ministry of Economic Affairs and Climate Policy [28], a set of nine essential building blocks has been identified for data sharing initiatives to support the emerging data economy. These building blocks enable organizations to be in control in utilizing and benefitting from the potential value of their data. The building blocks are listed in Figure 2.

The set of essential building blocks as listed in the figure forms a good functional foundation for the data sharing infrastructure. The following paragraphs in this section describe a structured architecture approach on how to realize and extend upon these building blocks, taking into account the various types of data sharing for the logistics sector as described in the previous section.

4.2.1 Towards a network-model approach

Data sovereignty is important for logistics data providers to share their confidential and potentially sensitive data. Currently, data sovereignty is mainly provided with specific solutions in individual data sharing ecosystems. In such a 'siloed' approach, data owners and providers are faced with both a threat of customer lock-in by their ecosystem providers and with major integration efforts on defining and enforcing data sovereignty requirements in case data sharing is needed in multiple ecosystems.

In the emerging data-driven economy, an alternative is needed. A single entry point for the data provider with common and agreed upon protocols for defining and enforcing terms-of-use for data sharing will give the data providers clear operational advantages in efficiency and effectiveness of managing his data sharing relationships over multiple ecosystems and sectors. As such, the network-model approach for data sharing is currently attracting major attention [43]. In the network-model approach, data sharing functions are provided as generic, re-usable services (building blocks) by independent organizations in the data sharing ecosystem, as depicted in Figure 3. These are referred to as intermediary roles. By agreeing upon the protocols for these data sharing functions, a single entry point (or gateway) for the data provider can be created for simultaneously managing and controlling his data sharing relationships. It builds upon the architectural principle of peer-to-peer data sharing between data provider and consumer, without the need for centrally storing or processing the data, enabling controlled data sharing with the data provider maintaining sovereignty over his data.

MESSAGE & DATA STANDARDS	REVENUE & COST MODEL	METADATA
Determining message and data standards for data sharing ensures that machines can easily process data without human intervention.	The revenue model ensures that the costs of initiating and operating a data sharing initiative are covered.	Metadata describes a dataset. Metadata arrangements make it easy for machines to navigate through datasets and information about the content, location, access rights, etc..
OPERATIONAL AGREEMENTS	CONNECTIVITY	AUTHORIZATION & CONSENT
Operational agreements determine the frameworks for the participating parties on the operational processes for data sharing (e.g. service processes).	Connectivity is the way in which different parties exchange data with each other or via an intermediary person or platform.	It is important that the data owner has control over his data. Authorization and consent are about getting and giving data access and usage rights.
LEGAL AGREEMENTS	GOVERNANCE	IDENTIFICATION & AUTHENTICATION
Legal agreements ensure that the rules for management and organization, data use, finances, operations, arbitration and technical aspects of data sharing are legal.	Good governance is essential for the confidence of participants in a data sharing initiative. Initiatives are often managed by a (consortium of) market party (s) and / or a trade association.	Identification and authentication is the process where something or someone claims an identity based on certain characteristics. An identity must be validated with a certain degree of certainty.

Figure 2. Essential building blocks as basis for responsible data sharing [28].

The network-model approach yields clear operational benefits in user-friendliness, complexity, efficiency and costs over traditional ('siloed') approaches. A network-model approach has previously been successfully developed and realized for infrastructural service provisioning in the banking and telecommunications sector.

4.2.2 Architectural levels of building blocks
In the architecture for (evolving towards) a flexible and extendible network-model approach three functional levels may be distinguished as illustrated in Figure 4.
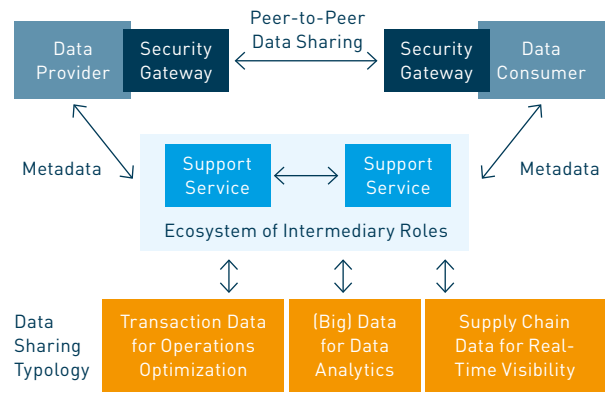
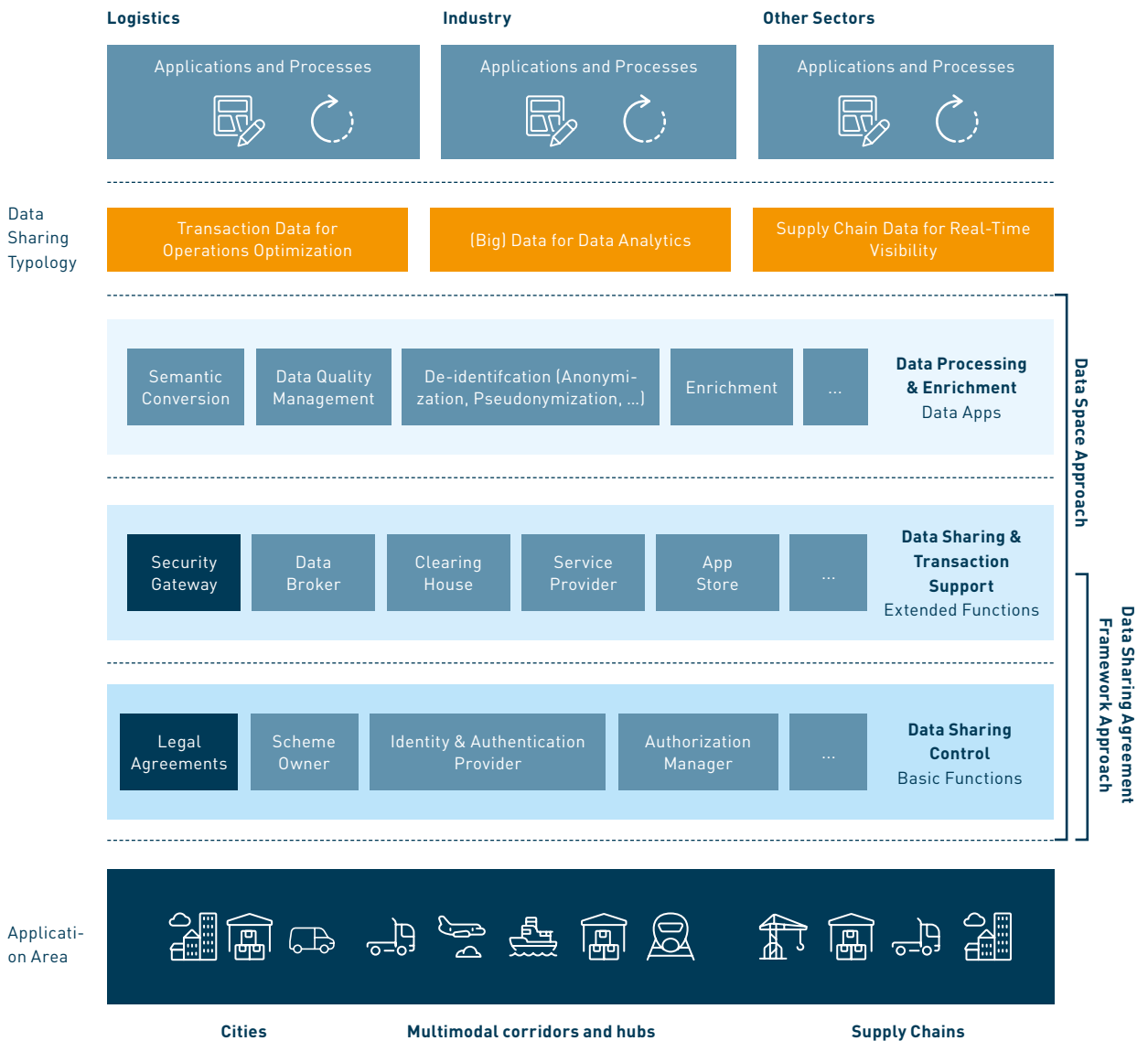Figure 3. An open network-model approach for controlled data sharing.

Figure 4. Functional levels with generic services (building blocks) in a logistics data sharing ecosystem.

The three functional levels each having a set of generic and re-usable services (building blocks) that are made available in a data sharing ecosystem [44]:

- **Data sharing control level**
  This contains the basic building blocks as required in a data sharing infrastructure providing data sovereignty and security. It includes legal data sharing agreements to be agreed upon between data providers and consumers, a scheme owner managing the subscribed organizations, identity and authentication providers and possibly an authorization function for defining and enforcing usage contracts (with access and usage control conditions) for individual data sharing transactions.

- **Data sharing and transaction support level**
  This contains an extended set of building blocks to support data sharing transactions, e.g. on registering and publishing available data resources (a 'data broker'), on administering and logging data sharing agreements and transactions for reporting, billing and conflict resolution (a 'clearing house') and enforcing the data sovereignty policies thereof (e.g. security gateway functions). Such supporting functions for data sharing transactions involve metadata which may be sensitive as well and therefore also requiring adequate data sovereignty and security measures [44] [45].

  In this context, it is good to refer to the FAIR concept and principles [46], on the Findability, Accessibility Interoperability and Reuse of data, arising from the management of scientific data but ever more being adopted in other sectors as well.

- **Data processing and enrichment level**
  This contains building blocks to process data prior to sharing or after being shared, e.g. for semantic conversions between data formats, management of the data quality and pseudonymization or anonymization. Such functions may be needed in complex application areas such as for artificial intelligence and machine learning [4]. They may be provided by means of (a library of) data processing data apps.

4.2.3 Agreement frameworks and data spaces

As Figure 4 depicts, the three levels of functionality can be related loosely to two approaches that currently attract attention for realizing a network model data sharing infrastructure: an agreement framework approach and a data space approach.

In an *agreement framework approach*, a joint (legal) data sharing agreement is agreed upon between data providers and data consumers, possibly including an authorization function for defining and enforcing usage contracts on the specific access and usage control conditions for individual data sharing transactions. An agreement framework may be used within an ecosystem of data sharing organizations, for example within the same sector. For the logistics sector in The Netherlands, the iSHARE initiative [47] provides such an agreement framework. It realizes a uniform series of agreements for identification, authentication and authorization. Similar agreement framework approaches in other sectors include MedMij [48], a system of agreements for the exchange of health data and Incoterms, an international standard on the rights and obligations of the buyer and seller in the international transportation of goods. An overview of agreement frameworks for various sectors in the Netherlands is provided in [28].

A *data space (or data market) approach* provides value adding functions as part of a broader system approach including the supporting functions for data sharing transactions and for data processing and enrichment functions as depicted in the figure. The International Data Spaces Association initiative (IDSA [49]) is currently gaining major European interest as data space approach. IDSA is also a member of DTLF. Value adding functions are provided by means of a (library of) data apps, executing within an IDS security gateway or IDS-connector. These allow flexibility and extendibility of the data space functionality. Individual organizations can 'personalize' it to their individual needs. Hence, it may be thought of as a managed and secure 'data sharing operating system', in analogy with a mobile phones operating system. An initial IDS implementation in the Netherlands is the Smart Connected Supplier Network (SCSN [50]), a fieldlab initiative of Brainport Industry to enable improved cooperation in the supply chain of many companies behind large high-tech companies in the Eindhoven area. Another example based on similar principles but based on a different technology is the AMsterdam data EXchange (AMdEX [51]), a data space initiative of the Amsterdam Economic Board for enabling local or (inter-)national collaboration on a transparent, open data market.

The agreement framework approach and the data space approach may be complementary. For a major part they pursue similar goals in realizing a network-model approach with a strong focus on data

sovereignty and trust in data sharing. An agreement frameworks main focus is on the rules that data sharing partners agree upon. A data space approach adds features for data sharing support and functional extensibility, still requiring a firm grounding in legal agreements.

However, regardless the complementarity of both approaches, their actual interoperability also depends on the architecture and implementation choices that have been made by both approaches. Especially, the choices on data sovereignty (access and usage) policies and their supporting authorization protocols will impact the level of interoperability and ease of migration. These considerations also hold for the iSHARE agreement framework initiative as developed by the logistics sector in the Netherlands (and currently being deployed and extended to other sectors and internationally as well) and the IDS as emerging European data space approach. Both iSHARE and IDS have recognized the potential to align and strive for an interoperable and complementary approach in which the strengths of both initiatives reinforce each other. This has resulted in a recent agreement to align the iSHARE and the IDS initiatives [52]. The goal is to provide (logistics) organizations a well-defined evolution path in which iSHARE provides an easy onboarding process with low barriers to participate as part of the growth path towards a more extensive data space approach. As both the agreement framework and data space approaches are developing in the logistics sector and beyond, the definition of an adequate roadmap, architecture and implementation choices is opportune. Specific attention is needed for hybrid situations in which a data provider and data consumer

may be using different approaches. A strategy for handling such hybrid situations is needed for interoperability and easy migration for end-users between these data sharing approaches. It will prevent complex migration trajectories on the longer term.

4.2.4 The cross-sector and cross-border interoperability challenge

The focus in this white paper is on the data sharing infrastructure within the logistics sector. It is to be realized that the logistics scope goes far beyond the boundaries of its own sector. The logistics sector is closely connected to other sectors. Moreover, it also has a major international component. This implies that a logistics data driven and data sharing infrastructure strategy and roadmap should be firmly embedded in and aligned with the developments and approaches taken in other sectors and countries. It will help in preventing from complex and costly migrations in the future. This specifically applies to determining its cross-sector strategy in developing and adopting a (combination of an) agreement framework approach and data space approach.

Obviously, the preference is an aligned definition and adoption of the same data sharing infrastructure approach within and across sectors. Nevertheless, this will in practice appear to be an utopia. A multitude of separate data sharing ecosystems, realized with their own specific implementation choices, is likely to emerge: various initiatives for both the agreement framework approach and the data space approach are being developed and deployed within various sectors of society. As data sharing should not be limited within a specific sector, interoperability of these initiatives is of key importance.

However, interoperability between separate data sharing ecosystems is complex as it spans a variety of aspects and perspectives to be taken into account. This complexity is represented by the new European Interoperability Framework [53] as developed by the European Commission. It provides guidance for meeting the interoperability challenges. As Figure 5 shows, it identifies four levels at which interoperability must be realized under an overarching integrated governance approach: legal, organizational, semantic and technical interoperability.

The right column in the figure shows the relevant aspects at each of the four interoperability levels for which interoperability between data sharing approaches has to be taken care of. These aspects reflect the components in the federative data sharing infrastructure as depicted in Figure 5.

Special attention is needed for the complex topic of interoperability of agreements between organizations active in different data sharing environments under various legal jurisdictions. This may require an approach that will enable negotiations on data sharing agreements between organizations. This aspect of negotiating data sharing agreements is mentioned, for example, in the reference architecture of the International Data Spaces (IDS) initiative [26], without currently giving concrete details of how this will be designed. A precondition for this is a formal semantic foundation that ensures that organizations unambiguously understand each other.

4.3 DUTCH 'COMMUNITIES-OF-PRACTICE'

Currently, pursuing the development, adoption and alignment of the data sharing approaches as described in the previous paragraph over various sectors, several Dutch data sharing 'communities-of-practice' are active:

- **Dutch Data Sharing Coalition** (DDSC, [54]): The ambition of DDSC is to drive the evolution towards cross-sectoral data sharing. So not only enabling data sharing between a few organizations for a specific application but aiming for a generic data sharing environment. The main focus is currently on a cross-sectoral data sharing agreement approach.

- **Working Group (WG) 'Data Sharing' of the Dutch AI Coalition** (NL AIC, [4]): Realizing that Artificial Intelligence (AI) will have impact on all business sectors, private lives and society, NL AIC has been founded as the catalyst for AI applications in the Netherlands. NL AIC has identified data sharing as one of its five cross-sector key enablers for improving the position of the Netherlands, realizing that AI applications need data to train, improve and execute. The main focus is currently on a cross-sectoral data space approach to support advanced data analytics.

These are two examples of current data sharing initiatives in the Netherlands. The logistics sector has been identified by these initiatives as a sector for which data sharing will be of specific interest.

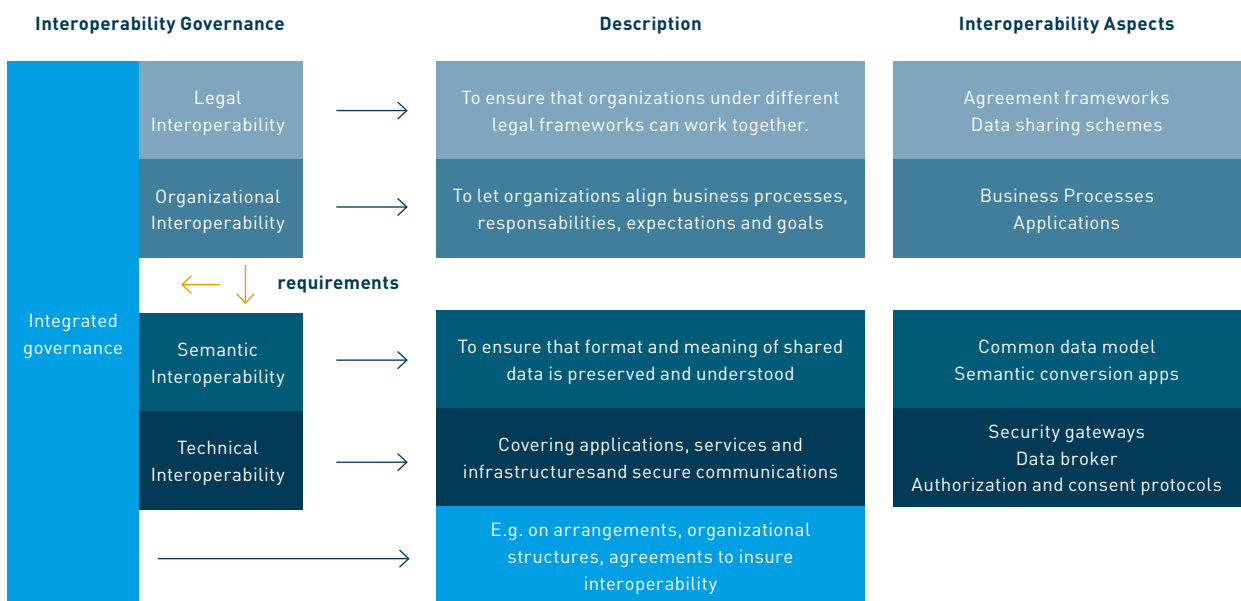| Interoperability Governance		Description	Interoperability Aspects
Integrated governance	Legal Interoperability	To ensure that organizations under different legal frameworks can work together.	Agreement frameworks Data sharing schemes
	Organizational Interoperability	To let organizations align business processes, responsabilities, expectations and goals	Business Processes Applications
	← ↓ requirements		
	Semantic Interoperability	To ensure that format and meaning of shared data is preserved and understood	Common data model Semantic conversion apps
	Technical Interoperability	Covering applications, services and infrastructuresand secure communications	Security gateways Data broker Authorization and consent protocols
		E.g. on arrangements, organizational structures, agreements to insure interoperability	

Figure 5. The new European Interoperability Framework [53].

4.4 THE WAY FORWARD: A DEVELOPMENT ROADMAP

In a process from development and first-time engineering to deployment of an initial operational implementation of an infrastructure for responsible and controlled data sharing as described in this white paper, the way forward is addressed from three perspectives:

- **Technology:** Designing the architecture necessary for sharing data, defining interfaces and information models, developing building blocks and demonstrating the overall system approach based on illustrative and representative use cases.
- **Organization:** Focusing on the strategy, alignment with data sharing developments in other sectors and architecture development. This requires a governance structure for both development and deployment of the logistics data sharing strategy.
- **Ecosystem:** Aiming at the adoption by organizations and market parties. Since data sharing as described in this paper deals with a multi-party

implementation, this implies an ecosystem. It is important to facilitate this ecosystem as well as possible, in preparation and realization of growth.

Figure 6 proposes activities on the roadmap from development and first-time engineering towards deployment and operationalization, distinguishing these three perspectives. It provides an initial view, building upon a vision of an ongoing evolution from a logistics data sharing agreement framework approach towards a data space approach.

The initial implementation of an infrastructure for responsible and controlled data sharing will add value to a broad set of current digitization solutions in the logistics sector. It will become part of the federation of solutions. For adoption, harmonization at both the technical and application level may provide clear advantages.
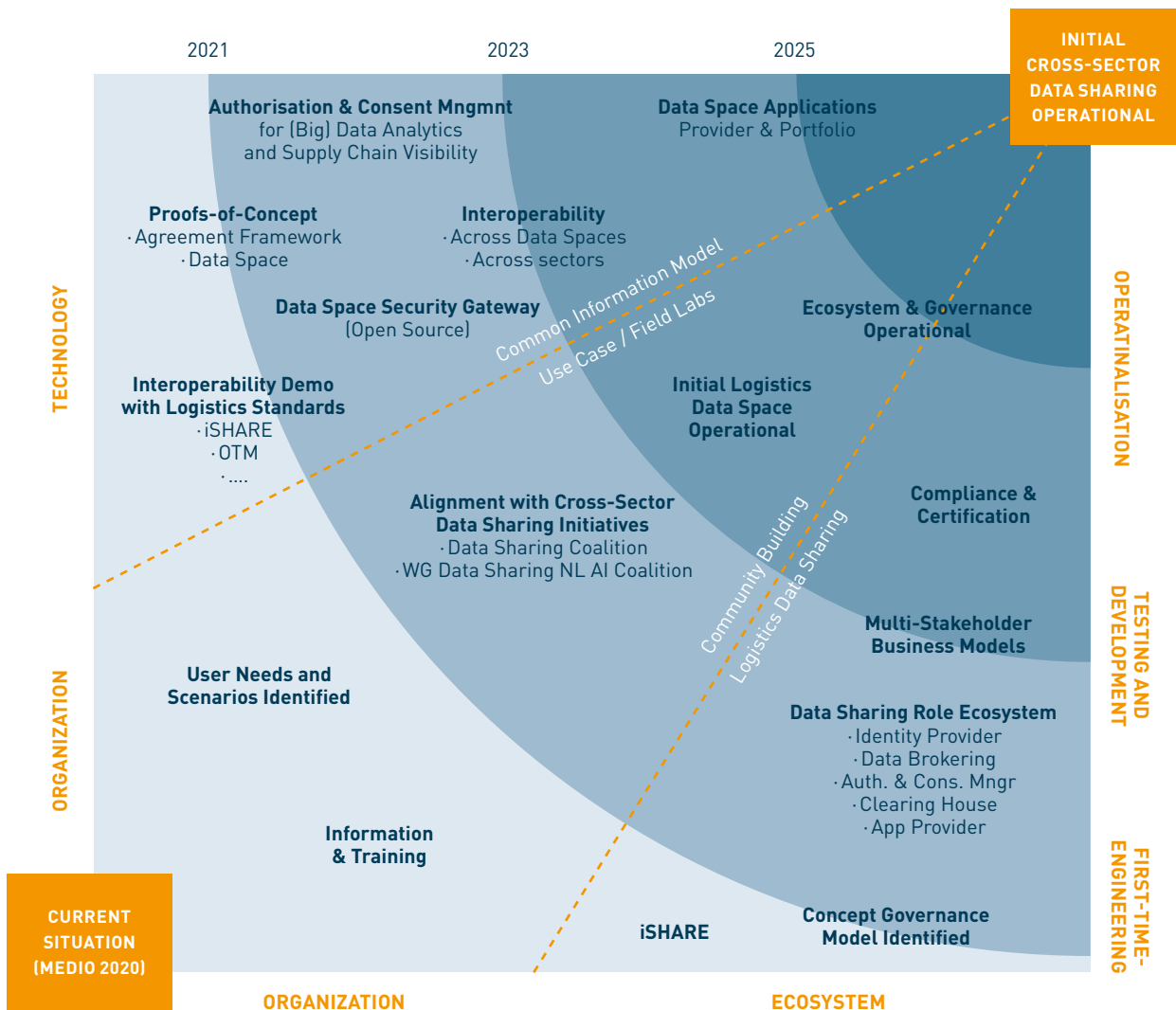

Figure 6. Roadmap for further development, deployment and adoption of data sharing infrastructure.

4.5 ADOPTION AND IMPLEMENTATION

Dissemination and valorization are essential to foster research, development, innovation, education, adoption and other relevant activities to progress and realize the ideas put forward in this white paper. In the Dutch innovation landscape, many approaches can be considered to organize these activities, varying from closed lab environments to field labs, urban test facilities and open living labs. This white paper aims to sparkle the dialogue about data sharing in logistics and shift towards implementation.

As stated in the introduction, data sharing remains a rather technical topic and its success heavily relies on adoption and implementation. This white paper has therefore been reviewed by stakeholders in the logistics sector to validate the ideas. Adoption and implementation however will require continuous attention and dialogue. Involvement of branch organizations is important to connect the ideas put forward in this white paper to the digital transformation strategies and agendas of their members. As such, the Evofenedex digitization strategy based on a four phase model (digitization, connectivity, transformation, disruption) provides an interesting option.

On a European scale there are also interesting initiatives to learn from for going towards adoption. An example worth mentioning is the successful organization model of the digital innovation hub (DIH) pursuing a similar German data sharing environment. The DIH brings together (physical, online and hybrid) stakeholders and builds an innovation ecosystem, offering companies the right knowledge, tools, infrastructure and coaching to explore use cases and initiate data sharing projects. Participants include research and technology organizations, government and branch organizations, standardization bodies, IT developers and solution providers, logistics market parties, small and medium-sized enterprises, start-ups and corporate start-ins. An equivalent Dutch data sharing living lab or digital innovation hub may prove valuable in facilitating adoption and implementation. It should be connected to research projects and linked to the Topsector Logistics' implementation program and initiatives as described in this white paper. The organization model provides a flexible delivery model for innovation and governance which is easily extendable to other Topsectors that are dealing with similar data sharing challenges.

5 CONCLUSIONS

From the analysis in this white paper, six main conclusions are drawn.

1. There is a momentum for data sharing in logistics
Ongoing digitization is rapidly changing the scene. Awareness for data driven business approaches is rapidly increasing. And disruptive events, such as COVID-19, stress the need for supply chain resilience and visibility. At the same time data sharing technologies are maturing. In various sectors this already results in a paradigm shift towards data driven collaboration ecosystems.

2. Data analytics and real time end-to-end visibility ask for additional data sharing functionality
To support the various types of data sharing in logistics, the current set of open logistics ICT-standards as promoted by SUTC [11] is not sufficient. Additional functionality on data sharing control, transaction support services and on data processing and enrichment is needed to embrace the merits of advanced data analytics (e.g. by means of artificial intelligence AI) and facilitate real-time end-to-end visibility.

3. An evolution path towards a data space approach is to be followed
On its evolution path, various levels of functionality are to be developed as generic, re-usable services (building blocks) in a managed and secure logistics data space. These include *data sharing control services* (such as legal data sharing agreements, data sovereignty and security functions), *data sharing and transaction support services* (such as clearing, billing, data brokerage and usage contract enforcement) and *data processing and enrichment services* (such as data quality management, semantic conversions and anonymization / pseudonymization).

4. Interoperability and scalability are key challenges to address
The logistics sector is closely connected to other sectors. Therefore, interoperability between various data sharing initiatives is very important. This applies to both interoperability between the agreement framework approaches (such as iSHARE) and data space approaches (such as a logistics data space to be developed) and between data sharing initiatives of the logistics sector and other sectors. Furthermore, scalability (both functional and in number of actors) must ensure that the data sharing infrastructure can grow and adapt to future demands to support new data streams and sharing processes.

5. Organize alignment and collaborate with (broader) data sharing coalitions
Various initiatives are currently working towards generic (cross-sector and international) data sharing supporting the European values of data sovereignty and privacy, e.g. the Dutch Data Sharing Coalition, the Data Sharing Working Group of the Dutch AI Coalition and the international IDS Association. For the Dutch logistics sector with its cross sectoral connections and international scope, it is of major importance to be aligned with these initiatives. This could be done under the adage 'generic when possible' and 'only specific (for logistics) when needed'. Nevertheless, it should be taken care of that the logistics specific data sharing interests, features and requirements will be embedded in and enabled by these generic data sharing initiatives. Therefore, an adequate set of representative and illustrative use cases is of major importance to identify the logistics specific requirements and setting the agenda.

6. Facilitate and orchestrate development, deployment and adoption
This white paper has sketched an evolution path for the logistics data sharing infrastructure. A roadmap has been proposed for further development, deployment and adoption, distinguishing between activities on technology, organization and ecosystem. Its success heavily relies on the adoption. As such, both development, deployment and adoption should be adequately orchestrated when executing the implementation program of the Topsector Logistics and the logistic sectors digitization strategy.

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APPENDIX: REPRESENTATIVE AND ILLUSTRATIVE USE CASES: ELABORATION

An initial set of logistics data sharing use cases has been provided in chapter 4, Table 1, organized along the axes of the high-level typology for logistics data sharing and the three Topsector application areas. These use cases are considered representative for a much broader set of logistics data sharing use cases.

Moreover, they may be considered illustrative in the requirements they have on the three levels of re-usable services (building blocks) in a logistics data space as depicted in Figure 4: the data sharing control services, the data sharing and transaction support services and the data processing and enrichment services. The relationships between these use cases and the levels of re-usable services in a logistics data space are described in this appendix in a qualitative manner. Figure 7 shows the resulting (high-level) mapping.

For each of the nine use cases in the figure, the following sections subsequently elaborate the use case and the mapping on the three levels of services for the logistics data space.

Use cases for the application area 'Cities'
Transaction data for operations optimization: Construction logistics
On city construction sites, material is lying on the building place (too long) and creates unsecure situations. People living close by experience noise disturbance and local traffic jams. Moreover, construction logistics is complex due to municipality regulations.

In most situations, a single main contractor is responsible for the overall construction activities with multiple subcontractors. Currently, a central logistics hub is often positioned close to the construction area, but on a more convenient location. Subcontractors can deposit their goods which (at the
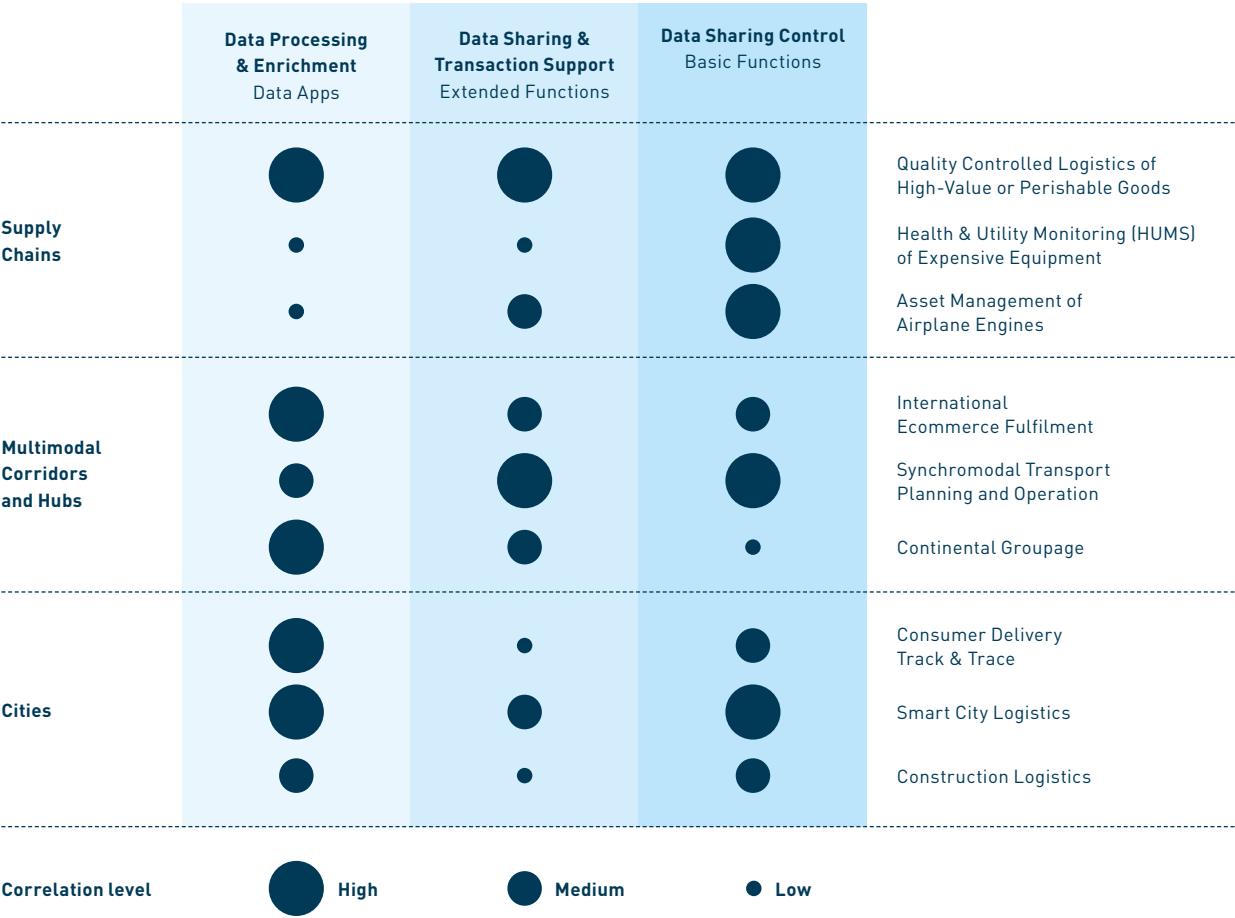

Figure 7. Mapping between the use cases (Table 1) and the levels of services (building blocks) in the logistics data space.

right time) will be transported to the construction site. This improves the truck utilization and reduces noise disturbance and local congestion.

The main contractor does all coordination during the construction period. A hierarchical relationship is built based on mutual trust, with a limited number of well-known subcontractors having legal agreements. Data transactions are administered by the main contractor. Therefore, the main emphasis in transactional data sharing is on data processing services with standardized semantic models for information exchange (e.g. the BIM standards) and data quality control and less on the data sharing control and transaction support functions.

(Big) data for data analytics: Smart city logistics

In inner city shopping areas, many shops are located close to each other and may be difficult to reach. Multiple logistics service providers have to deliver goods. As a result, the streets may be congested with multiple trucks with a less than full truck load. In addition, smart city logistics may become complex due to city regulations, e.g. on restricting the time-slots in which it is allowed to supply shops.

City distribution centers are currently gaining traction, e.g. located in the outskirts of a city. In the cross docking center full truck loads (per street) can be achieved. Cross docking requires coordination of the physical goods flows, supported by adequate digital processes.

Data sharing is characterized by the absence of a single main coordinator: non-hierarchical relationships arise with many, changing, stakeholders, both in terms of suppliers of goods, the shops and of transport providers. There is a huge shift from bilateral relationships towards a cross chain approach to further improve the truck loads and minimize the number of truck movements in the inner city. A dynamic data sharing environment is required for doing the analytics over the data provided by this broad diversity of stakeholders. Moreover, these stakeholders have confidentiality requirements as they do not want their data to be available to potential competitors. This leads to strict demands on data sovereignty and security as provided by the data sharing control and transaction support functions, requiring a standardized approach of identification, authentication, and authorization to ensure trust. Simultaneously, functions for management of semantics and data quality (as provided at the data processing level) will improve the result and efficiency of the overarching orchestration processes.

Supply chain data for real-time visibility: Consumer delivery track & trace

In the distribution and logistics for consumer goods, track and trace concerns a process of determining the past, current and time-predicted locations (and other information) of a unique item, e.g. a parcel. For consumers, accurate reporting on the expected arrival of parcels leads to improved user satisfaction. The same is true for the pick-up of parcels to be sent or returned. Real-time locating systems (RTLS) are used to identify and track the location of objects in real time, providing consumers real-time visibility into the status, location and expected delivery times for their orders.

To support this consumer delivery track & trace, major platform players have developed their own proprietary data sharing infrastructures. Simultaneously, a trend is ongoing to also move towards an ever more distributed approach in which a variety of platforms collaborate to optimize the overarching supply chains. This trend becomes ever more important when taking into account the optimization of the delivery process for the 'last-mile' city environment with a diverse, dynamic and complex landscape of stakeholders. Again, functions for management of semantics and data quality (as provided at the data processing level) will improve the result and efficiency of the overarching orchestration processes. To some extent, basic data control functions on identification and authentication are relevant as well.

Use cases for the application area 'Multimodal corridors and hubs'
Transaction data for operations optimization: Continental groupage

For combining cargo – often referred to as less than truckload (LTL) shipments - from more than one shipper and/or to more than one consignee for shipment together, usually in a single truck, LTL carriers use "hub and spoke" operations: small local terminals are the spokes ('end of line'), and larger more central terminals are the hubs (also called Distribution Centers or DC's). Spoke terminals collect local freight from various shippers and consolidate that freight onto enclosed trailers for transporting to the delivering hub terminal, where the freight will be further sorted and consolidated for additional transport (also known as linehauling). Combinations of LTL-shipments are being made to optimize linehaul transport. This includes volume and weight combinations (combining high-volume-low-weight shipments with low-volume-high-weight shipments), cargo characteristics (e.g. dangerous

goods and packed food), customs regime and inspection risk (critical machinery equipment and excise duty shipments), requested delivery dates, etc.. These groupage or LTL carriers often offer a certain service frequency on international lanes and need a certain utilization rate to make a positive margin.

By shortening the gap between the cut of time to deliver LTL shipments at the spoke terminals and the departure time of the linehaulier from the hub terminal, the consolidation potential is higher and more optimal combinations can be made. Obviously, this requires a sound digitized transaction system of transport booking data and efficient optimization algorithms. Basic data sharing control functions are needed to support online booking via a web interface. But rather the data processing enrichment functions can make the difference in making profit or not, putting emphasis in transactional data sharing on data processing services. Data quality management features can for instance identify non-logical weight/volume combinations, which can be validated upfront before being confronted with surprises during cross-dock operations at the hub terminal. The group of stakeholders is in general well-known, with relatively few changes. This leads to less strict demands on data sharing control functions, whereas transaction support functions for administering truck loads is relevant.

(Big) data for data analytics:
Synchromodal transport planning and operations
Synchromodality is about offering simultaneously multiple inland waterway transport (IWT), rail and road services along a corridor, optimize multimodal capacity, stimulate mode-neutral bookings and utilize the most suitable transport mode for bookings. It requires a complex visibility infrastructure and advanced analytics to dynamically allocate the bookings to the right transport mode in order to optimize the network services. Think of using historical transport data to calculate estimated times of arrival (ETAs), port congestion patterns to predict waiting time before berthing, real-time data to monitor goods and assets in transit, fleet availability, infrastructure capacities, public work (maintenance) status, etc.

Take for instance an export container booking from Ludwigshafen to Rotterdam, which needs to be at the export terminal at a given closing time in order to catch its scheduled deepsea carrier connection. The preferred way may be to ship the container to Rotterdam using IWT. But in this case the booking

was received rather late, the next inland vessel departure has planned to unload containers in three other deep-sea terminals first, and port congestion for inland vessels at two of those terminals is expected to further increase the coming days. As a result, it is better to ship this particular container by truck. Vice versa, another booking was received some days in advance. Normally this customer is booking four containers per week using rail transport to have acceptable transit times in a sustainable fashion. But in this case the closing time allows for moving the containers via inland shipping, since port congestion is not foreseen. And the next vessel departure has enough spare capacity, whereas the next two days can be used to fill the available rail service capacity with other bookings.

The synchromodal transport planning system is fed by customer interfaces for online bookings. It uses advanced planning algorithms taking into consideration remaining capacities for the various multimodal transport services and anticipates on possible delays. Data quality and agreed upon semantics improve the result and efficiency of the complex synchromodal data analytics process. Many data sources and stakeholders are involved, with dynamic relationships. In combination, adequate services in all three data sharing levels (data sharing control services, the data sharing and transaction support services and the data processing and enrichment services) are required.

Supply chain data for real-time visibility:
International ecommerce fulfilment
International ecommerce is growing rapidly. Nationally oriented platforms and webshops (e.g. Bol.com) see global platforms entering the market (e.g. Ali Express, Amazon etc). Part of the market is driven by shortening order fulfilment (order before 23:00, deliver next day). This puts challenges on the order picking, packing, distribution and delivery processes. One may claim that major platform players have developed their own proprietary data sharing infrastructures to facilitate their own platform economy and onboarding customers, suppliers and logistic service providers. But the world is heading towards a large variety of different platforms, which use each other to strengthen their propositions. A large group of webshops, warehouse operators, freight forwarders and logistic service providers do not want to rely on a single platform operator and want to offer their services in a multi-platform environment.

This puts requirements to the data sharing infrastructure. The front-end (webshop) requires the basic data sharing requirements such as identity management, authentication and authorization. And customer order data is subject to privacy, so data processing and analytics should be anonymized in order to preserve this privacy. Extended data sharing functions allow for offering a platform for 3rd party sellers and clearing house functionality handles automated financial transactions. Platform interoperability requires standardization on data semantics. Again, in combination, adequate services in all three data sharing levels are required, with strong emphasis on the data processing and enrichment services due to the diverse solution landscape.

Use cases for the application area 'Supply Chains'
Transaction data for operations optimization: Asset management of airplane engines

Airline companies operate a large number of airplanes with engines from different manufacturers. Their interest is to continuously monitor the performance of these engines, in combination with the performance of the airplane itself and measure emissions, fuel consumption, maintenance and repair cost, wear, etc.. Hence, they want data from each individual engine to analyze their status but also to compare engines on different planes from the same manufacturer and even across engines from different manufacturers on similar planes. For the analysis of the engine data they must rely, in part, on the proprietary data processing and algorithms of the manufacturers themselves. These manufacturers want to have the same data on their engines to look for behavior, anomalies and operational performance figures. However, they do not want their engine's data and the analysis results to fall into the hands of their competitors. Therefore, they will not just provide airliners their analysis tools.

This use case has several specific data sharing features. Processing data from an individual engine has a limited use value, whereas processing data from all the engines of a particular brand and type has a much higher use value for multiple stakeholders. Multiple stakeholders (airline company, aircraft builders, aircraft engine builders) want access to data sets that are generated during operation of a system, the meaningful analysis of which depends on context information that must be supplied by another stakeholder. There is a serious commercial confidentiality issue to address. For instance, data that could reveal performance issues of one brand of engine must not be accessible for the manufacturer of another brand of engine. The engine manufacturer is the only one that can integrate all the data from its engines. For commercial airplanes there are regulations that require engine manufacturers to provide part of the engine generated data via the digital data bus of the airplane for in-flight and off-line monitoring, but the reason is safety related and not performance related. Some of the data items have a real-time character, i.e. they must be available in a timely fashion, because the planning of in-operation interventions depends on them. Other data have a non-real-time character, but still must be collected at regular intervals, whereby the necessary repeatability period may differ per data item. Any data item of such a high tech and complex device such as an airplane engine, in use in a safety critical and economically very competitive environment, is confidential in nature and access must be secure and restricted. Therefore, strong emphasis in this use case is on data sharing control level of services.

(Big) data for data analytics: Health & utility monitoring of expensive equipment

This use case involves one or more users of a very expensive and complex piece of machinery or device together with the supplier of those machines/devices, e.g. an advanced naval radar system that is delivered by one single supplier to multiple customers. When operated, each of these radar systems generates data about itself and data about the environment in which it operates. Both types of data contain information about the health status of the equipment and about its operational performance. The supplier can use this data to propose an optimal and minimum cost maintenance and support scheme for each individual radar system, matching the operational performance requirements of the individual customer. This sort of maintenance proposition is called 'predictive maintenance'. It uses a combination of heuristics and statistics based on the analysis of many (similar) systems, but adapted to the specific conditions and behavior of a single individual system.

Typical data sharing features for this use case are: Data from multiple users/owners is shared with a single supplier for advanced data analytics. The different users are not allowed to be aware of each other or have access to another user's data. Confidentiality of the data is to be maintained. The supplier can have access to the place of origin of the data and the systems that produce the data are not connected to the outside world when operational.

This is for security and safety reasons. Data from such systems is organized in specific datasets that are constructed and configured for operational and local use and not specifically filtered for other use outside of the operational scope. This always means that the datasets contain data elements that may reveal sensitive information that must not be shared. Instead of cleaning the data at the source, that sensitive data should be unable to be processed. Not all that the supplier may learn from the data, is allowed to be learned from the data. Again, strong emphasis in this use case is on data sharing control level of services.

Supply chain data for real-time visibility: Quality controlled logistics of high-value or perishable goods

Currently, for quality-controlled logistics of high-value and/or perishable goods (e.g. fruit, expensive art, radioactive medical supplies) there are plenty of solutions to place a tracker-with-sensors to monitor transport conditions in run-time to be able to respond as soon as the 'health' of the payload is at risk. Such tracker systems need continuous and real-time monitoring of the goods along the logistics chain: from transport, to quality inspection at the final destination, and every step of the way in between. Not only by the transporter that has momentary responsibility, but by all relevant logistics chain partners, from producer to buyer. At all times the whereabouts and status of the goods must be known. Smart decision making based on these data determines the possible actions to be undertaken in case something is not right. The logistics partner that has the momentary responsibility for the transport has the lead in the decision process.

The data sharing features for this use case include: A sharing solution is needed that takes care of the real-time streaming of status data and added context data (such as location, movement, or the absence of movement, etc.). The data is sent to a data-handling server, owned by a logistics service provider that collects, groups and routes this type of data. Who now owns the individual data items and the stream? Information on where the transport is and how the transport is progressing, should be on a need to know basis only, to avoid malicious interventions en-route. This holds not only for the transporter that has momentary responsibility, but by all relevant logistics chain partners, from producer to buyer. Moreover, reliability of data and the authenticity of the data source are extremely important issues, since the data is run-time data and meant to be actionable. Obfuscation of non-necessary data is also an issue, because some data elements must be shared with 'unknown' parties in the supply chain, e.g. in case repair of a cooling unit of a truck en-route is needed from a never before used local maintenance company, data about the location and current itinerary and rendezvous point of the truck must be shared, for this intervention only. But no other sensitive data must be shared. In combination, adequate services in all three data sharing levels (data sharing control services, the data sharing and transaction support services and the data processing and enrichment services) are required.