Aligning Dutch logistics data spaces initiatives to the international data spaces: Discussing the state of development

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Aligning Dutch logistics data spaces initiatives to the international data spaces: Discussing the state of development

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Abstract

As the potential benefits of implementing International Data Spaces (IDS) become more evident, several initiatives attempt to implement Logistics Data Spaces (LDS) and search alignment with federated IDS infrastructures. More specifically, the Topsector Logistics Action Agenda (2021-2023) proposed a research and development roadmap outlining the development of a sector-wide logistics data-sharing infrastructure, its essential building blocks, and nine illustrative use cases for practitioners. However, such an ambitious roadmap requires a significant change in the current system regime, raising new challenges throughout the four enterprise interoperability layers recognized by the European Interoperability Framework, i.e., technical, semantic, organizational, and legal. This discussion paper provides an overview of completed and current research endeavors to promote enterprise interoperability in the context of LDS and searches alignment with the IDS vision and reference architecture model. Therefore, we survey work in progress, preliminary results, lessons learned from research initiatives, policymaking, roadmap realization, and industry challenges in this area. The contribution of this discussion paper is threefold. First, it summarizes the leading European developments and data-sharing initiatives. Second, it elaborates on the established roadmap, state-of-the-art LDS initiatives, and relevant achievements in the macro-context of IDS. Third, we report on some of the main lessons learned. The paper summarizes preliminary results and lists immediate research opportunities, industry challenges, recommendations for further roadmap realization, policymaking, and alignment with related international developments.

Keywords

Enterprise Interoperability, International Data Spaces, Logistics Data Spaces, Logistics.

1. Introduction: setting the scene

Data is essential in today’s information society and a valuable asset for economic development, competitiveness, and innovation. Data sharing is vital to realize benefits and poses challenges and risks. Data sharing requires interoperability on different levels (e.g., legal, organization, semantic, technical), supporting infrastructures, and governance (e.g., privacy, ownership). Data spaces are positioned as the cornerstone by the European Commission (EC) to make data widely available across sectors and countries, enabling involved organizations and individuals to leverage the benefits of data sharing while ensuring data sovereignty.

The EC developed a data strategy that “puts people first in developing technology and defending and promoting European values and rights in the digital world” [1]. More specifically, the data strategy aims at creating a single market for data that contributes to global competitiveness and data sovereignty. In line with this strategy, data spaces, currently under development, will make data widely available while enabling data owners to remain in control. The Data Governance Act [2] supports the development of data spaces in strategic domains (e.g., Healthcare, Environment, Energy, Agriculture,
Mobility, Finance, Manufacturing, and Public Administration). This may contribute to building trust, skills, supporting mechanisms to make data widely available, and overcoming technical issues. Recently, the EC proposed the Data Act to make the EU leader in the data economy and harmonize the rules regarding fair access to and use of data [3]. These acts complement established acts such as GDPR.

The EC actively encourages governmental-business data sharing and established working groups for horizontal or specific topics and involvement of Small and Medium-sized Enterprises (SMEs), that account for 99% of the businesses in Europe [4]. A recent staff working document provides an overview of the state of development, including legislation, regarding EU data spaces and illustrates the largescale development of common data spaces for strategic domains and specific applications such as the Green Deal [5]. The EC will further report on results in 2023. An SME panel consultation [6] yielded 979 responses, revealing that 33% of the respondents retrieves data from other organizations, of which 39% experienced difficulties. The difficulties are mainly due to unfair or unreasonable practices regarding data access, e.g., license fees, unfavorable contracts, lengthy processes, and technical problems [6].

The International Data Spaces (IDS) initiative [7] established Reference Architecture Model (RAM), including supporting technologies, to enforce data sovereignty and set the global standard for data spaces. Furthermore, the International Data Spaces Association (IDSA) contributes to developing industry testbeds, regional ecosystems, supporting certification procedures for software developers, new business models, fostering adoption, with particular attention to SMEs, and providing governance models. The data spaces radar shows various data spaces under development and their maturity levels [8]. The IDS initiative also connects to EU cloud development initiatives, e.g., GAIA-X [9].

There are several initiatives currently in progress to develop platforms and pilots for large-scale implementations, including, but not limited to, Open DEI [10], Fiware [11], FEDeRATED [12]. Recently, Fiware, iSHARE, and FundingBox launched the i4Trust initiative [13] that aims to boost data sharing and facilitate SMEs innovation capability by creating data spaces. Data sharing is also part of the Topsector Logistiek 2021-2023 action plans [14]. A roadmap is developed based on leading research projects to build the sector-wide data-sharing infrastructure for the Dutch logistics industry [15]. This roadmap, discussed in Section 2, aims to align IDS developments to the Dutch logistics industry's current established standards and existing ecosystem.

Several research projects and government initiatives are currently instigating the development of multiple IDS use cases. The Smart Connected Supplier Network (SCSN) [16] is one of the first IDS-based data spaces operational in the Netherlands. Following European developments, there are several governmental initiatives. The most important is the development of the Basic Data Infrastructure (BDI) as part of the Digital Transport Strategy (DTS) [17] of the Ministry of Infrastructure and Environment. The ambition of the DTS is to have fully digital, paperless transport within ten years, realize one governmental platform for logistics, and implement EU policies (e.g., Benelux electronic Freight Transport Information (eFTI)). The Data Exchange Facility Logistics (DEFLOG) project develops governmental data sharing applications [18].

On the other hand, many industrial data ecosystems are operational, including Value Added Networks (VANs), Electronic Data Interchange (EDI) brokers, and platforms that connect global ecosystems. These VANs, EDI brokers and platforms may utilize established international industry standards, such as GS1. On a national level, semantic standards are developed. Standardization bodies like SUTC [19] and DCSA [20] establish and promote standards.

The level playing field is changing daily. The plans to realize the envisioned sector-wide data-sharing infrastructure will require a large-scale system change, raising unpredicted challenges regarding enterprise interoperability. Such a system change is challenging, given the current siloed and scattered IT landscape and state of digitalization, especially in SMEs [21]. The current use of VANs, EDI brokers, and platforms will pose adoption challenges and require migration and transformation. More specifically, no neutral orchestrator in the current system regime fulfills the IDS clearinghouse role. This discussion paper provides an overview of completed and current research endeavors to promote enterprise interoperability in LDSs and search alignment with the IDS RAM.

The remainder of this paper is structured as follows. Section 2 summarizes the roadmap development and status of current research projects. Section 3 reflects on the realized results by drawing lessons learned for future developments. Finally, Section 4 concludes with research opportunities, industry challenges, recommendations for policymakers, and alignment with international initiatives.
2. Status quo: Roadmap realization and status

This section describes a research roadmap to realize the IDS vision, reports on four important research projects that develop LDS infrastructures for the Dutch Logistics sector and related research projects promoted by IDSA that together form the foundation to integrate LDS and IDS developments.

2.1. Roadmap

In 2020, the Logistics Data Sharing Infrastructure whitepaper [15] was published, involved the principal researchers from four leading research projects, DL4LD [22], ICCOS [23], and CLICKS [24], working in close collaboration with several experts, branch organizations, standardization bodies, and stakeholders from the Topsector Logistiek and TKI Dinalog.

The authors emphasize the relevance and importance of data sharing in the Logistics sector, the need for an architecture for developing a sector-wide data-sharing infrastructure, related policymaking and development initiatives, a roadmap for implementation, and possible technology adoption strategies. The authors described a high-level architecture and proposed the essential building blocks to build it along with nine illustrative data-sharing use cases from the Logistics sector.

In 2021, the DASLOGIS [25] project started to realize (parts of) the roadmap and instantiate the Dutch Logistics Data Space (DLDS) and run pilot projects with industrial partners.

2.2. Research projects

The DL4LD project (2017) developed a blueprint of a reliable data-sharing infrastructure for logistics. A focal point is on maintaining the sovereignty of the data owner over the access, usage, processing, and proliferation of his potentially sensitive data. DL4LD elaborates a reference architecture for trustworthy, multi-lateral, data sharing in an open, distributed, infrastructure. Demonstrators and field labs are developed to convince the industry about the technological readiness.

The ICCOS project (2019) aims to design a detailed LDS architecture, including guidelines and implementation models, as a foundation to develop Artificial Intelligence Agents (AIA) to support (semi-)autonomous coordination of supply chains and operational planning forecasting, and replenishment processes. The high-level architecture for an industry platform is positioned and presented in [26]. The first version of the industry platform is realized and is based on the Open Trip Model (OTM)[27]. Prototypal AIAs are developed and tested with industry partners [28]. Current work incorporates the iSHARE trust framework [29] and searches alignment with the IDS RAM. The adoption of IDS is studied, leading to a maturity assessment and decision support tool for organizations interested in joining IDS [30].

The CLICKS project aims to tackle intra-data space interoperability issues on the organizational and semantic interoperability levels, focusing on federated interoperability for SMEs [31]. It proposes two mechanisms to address these issues. First, a connector store will help companies discover and select data connectors suitable to enforce their data sovereignty requirements. Second, an interoperability simulator will help them forecast pitfalls that might precede the formation of data-sharing agreements in IDS ecosystems. Three artifacts will support the implementation of the data connector store: (1) a reference enterprise architecture described using the Archimate specification [32] to guide developers identify critical organizational and software components necessary to deploy an IDS communication infrastructure; (2) an ontology to support discovery and selection of data connectors; and (3) a proof-of-concept implementation to demonstrate the feasibility of the reference enterprise architecture with an illustrative business case. The last artifact will combine privately owned enterprise integration facilities from industrial partners with publicly available data connectors from the Fraunhofer Institute [33]. There is ongoing research on the design of the interoperability simulator to be implemented as a digital twin. Value models describing organizational configurations of IDS ecosystems will provide input for the digital twin. These models also aim to make organizational guidelines suggested by the IDS RAM and the rule book more understandable to SMEs. There is ongoing research on formulating
the digital twin architecture, the explorative competency questions it could help companies respond to, and tools for implementation and deployment.

The DASLOGIS project addresses inter-data space connectivity issues, as the flow of sensitive data cроссcuts inter-organizational boundaries, business sectors, and ecosystems. The project focuses on three types of data: logistics operational data, big data sharing for data analytics, and supply chain visibility data. The project advocates the EC’s vision of data sovereignty and control, i.e., to grant users rights, tools, and skills to stay in complete control of data disclosure. The project foresees three scenarios of data space interoperability: (1) intra-space connectivity between iSHARE actors; (2) inter-data space connectivity between one iSHARE data consumer and one IDS data provider; and (3) inter-data space connectivity between IDS and iSHARE ecosystems. Despite recognizing that inter-data space attempts to communicate may lead to interoperability issues ranging from technical to legal mismatches, the project’s state-of-the-art points to more prominent activity on treating technical and semantic interoperability issues.

The project proposes a solution for inter-data space connectivity based on proxies on the technical interoperability level. A proxy works with a well-defined API, translating requirements and specifications from a data-sharing domain to another. A harmonization domain is a network of proxies maintained by the organizations cooperating in data spaces. Current work focuses on specifying the harmonization domain, formulating an illustrative case in green loans, and deploying a proof-of-concept implementation. On the semantic interoperability level, the research conducted in the project revealed that semantic conversion between industrial standards for exchanging Logistics data (e.g., OTM and SCSN) is not always efficient. One possible solution is to merge instead of aligning the terminologies into a networked ontology or knowledge graph. There are still practical barriers to adopting semantic Web technologies in the industrial sector, such as complexity, scalability, performance, mismatches with the current IT stack, lack of knowledge. The project identifies at least four essential elements to cope with semantic interoperability issues in inter-space connectivity: (1) an IDS information model to describe the organizational elements of an IDS ecosystem; (2) data models and vocabularies to establish a domain language; (3) data connectors and data transformation applications; and (4) vocabulary providers and federated catalogs for metadata discovery and publication. The project recommends the Semantic Treehouse Platform [34] to support business ecosystems and sector bodies with facilities to publish, share and maintain data models, ontologies, schemas, and taxonomies. Still, it has provided no proof-of-concept implementation thus far.

2.3. Related IDSA projects

Related work is explored in the Logistics community of the IDSA. In 2017, the Fraunhofer Institute developed a reference use case for logistics to demonstrate the IDS RAM and its components in a standard logistics scenario. The IDSA also created a Logistics community to stimulate the development of use cases and pilots. In 2019, a position paper was released regarding the challenges and potentials of a logistic data space, illustrating various possible applications [35]. The data space radar highlights several pilots in the logistics domain and supply chain. In line with the EU staff working document, several common data spaces are developed, including a shared data space for logistics and mobility. Practical guidance is offered in the form of a use case playbook [36] and data-sharing canvas [37].

3. Lessons learned

Based on the results and findings from research, this section reflects lessons learned. The primary learning is that the data space field is constantly and rapidly changing on different levels. Therefore, active monitoring of the EC strategy, policy and regulations, and (inter-)national research projects and development initiatives by governments and industry is crucial to align with the latest developments.

Another learning is that most initiatives focus on policymaking, reference architectures, infrastructure, and governance. Currently, attention is given to awareness building, adoption, and migration/transformation strategies. Each initiative has specific transformation pathways, e.g., top-down policy development and enforcement versus community building, that should be explored and evaluated. SME enablement programs will require significant efforts and long-term commitment.
Existing data ecosystems have a large installed base and might resist adopting a data spaces approach. Current VANs, EDI brokers, and platforms might face high costs to change their technology concept and required certification procedures may limit their freedom to operate. The current system regime has no evident party to fulfill the clearinghouse role. Here, the Energy or the Financial industry could provide best practices and learnings.

4. Conclusion and future work

This section summarizes the main results and concludes with research opportunities, industry challenges, recommendations for policymakers, and alignment with international developments. Figure 1 visualizes policymaking, developments initiatives, research projects on the EU and national level.

![Figure 1. Overview of European and Dutch initiatives and projects for data spaces.](image)

The roadmap, discussed in Section 2, gives direction for research and initial development of a sector-wide data-sharing infrastructure for the Dutch logistics industry, but does not encapsulate the necessary system change and long-term vision. The development and large-scale deployment of LDS and a sector-wide data-sharing infrastructure will require a long-term commitment (like the DTS). This exceeds the scope of individual research projects and requires strategic support of the government, branch organizations, and standardization bodies.

Some of the main recommendations for policymakers from the Dutch Logistics sector include: (1) search for collaboration between governmental initiatives (such as the DTS, BDI and DEFLOG) and industrial research projects to co-develop inspiring use cases and raise awareness; (2) start an SME consultation, together with branch organizations and researchers, regarding data sharing challenges and needs for implementation support; and (3) involve SUTC to share the IDS standard and integration with standards for paperless transport, OTM, iSHARE, and other initiatives. Furthermore, an effective alignment of initiatives from the Dutch Logistics sector with the IDS vision will require more engagement of the Dutch representatives in actively contributing to the Logistics community of the IDSA and make current uses cases and pilot implementations visible in the data spaces radar.

There are also research challenges and opportunities to address. From a research perspective, there are gaps to be explored in cross-sector data space interoperability (e.g., between SCSN and DLDS); semantic interoperability of OTM and DCSA with GS1 standards, and revamping VANs, EDI communication, and non-IDS-based platforms to IDS data spaces. From the industrial perspective, there is more work to do on: (1) harmonizing currently established data ecosystems, e.g., VANs, EDI brokers, and platforms; (2) building awareness of the benefits of the IDS vision by promoting inspiring use cases and implemented IDS-based data spaces; (3) seeking for a neutral orchestrator in the Logistics sector that could fulfill a clearinghouse role; and (4) leveraging capabilities and resources required for the development of LDS, e.g., IT and legal expertise.

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