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 use cases and search alignment with federated IDS infrastructures. This discussion paper provides an overview of completed and current research endeavors in the Dutch logistics industry and searches alignment with the European data spaces developments and the IDS reference architecture model. Therefore, we surveyed work in progress, analyzed preliminary results and 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, data-sharing initiatives, and relevant achievements in the macro-context of IDS. Second, it elaborates on the established roadmap and state-of-the-art research initiatives in the Dutch logistics industry. Third, it presents a visual overview of current developments and reports on the main lessons learned. This 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

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 but also poses challenges and risks. Data sharing requires interoperability on various levels (e.g., legal, organization, semantic, technical), supporting infrastructures (e.g., centralized, federated), 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.

In the Netherlands, related to the Topsector Logistics Action Agenda (2021-2023), a research and development roadmap was proposed outlining the development of a sector-wide logistics data-sharing infrastructure, its essential building blocks, and nine illustrative use cases for practitioners. However, realizing such an ambitious roadmap requires a strategic long-term commitment and significant changes in the current system regime, raising new challenges regarding enterprise interoperability. This discussion paper provides an overview of completed and current research endeavors in the Dutch logistics industry and searches alignment with the European data spaces developments.

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The remainder of this paper is structured as follows. **Section 2** sets the scene by summarizing European data spaces developments. **Section 3** summarizes the Dutch data spaces developments, research roadmap and status of current projects. **Section 4** visualizes data space developments and reflects on the main lessons learned. Finally, **Section 5** concludes with research opportunities, industry challenges, recommendations for policymakers, and alignment with international initiatives.

2. European developments and projects

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), which 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 large-scale development of common data spaces for strategic domains and specific applications such as the Green Deal [5]. The EC will further report on data space developments and results in 2023. An SME panel consultation [6] yielded 979 responses, revealing that 33% of the respondents obtains data from other organizations, of which 39% experienced difficulties. The difficulties are 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 the Reference Architecture Model (RAM), including supporting technologies, to enforce data sovereignty and aims to 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 [8] shows various data spaces under development and their maturity levels. The IDS initiative is connected to EU cloud development initiatives, e.g., GAIA-X [9].

There are several European 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.

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 applications [14]. The data space radar highlights several pilots in the logistics domain [8]. 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 [15] and data-sharing canvas [16].

3. Dutch initiatives and research projects

In line with the European developments, there are currently several research projects and government initiatives instigating the development of multiple IDS use cases. The Smart Connected Supplier Network (SCSN) [17] is the first IDS-based data spaces operational in the Netherlands.

The most important governmental initiative is the development of the Basic Data Infrastructure (BDI) as part of the Digital Transport Strategy (DTS) [18] 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 [19].

Data sharing is also part of the Topsector Logistiek 2021-2023 action plans [20]. In 2020, the Logistics Data Sharing Infrastructure whitepaper [21] was published, involved the principal researchers from three 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 logistics 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. The roadmap aims to align IDS developments to the Dutch logistics industry's current established standards and existing ecosystem. In 2021, the DASLOGIS [25] project started to realize (parts of) the roadmap and instantiate the Dutch Logistics Data Space (DLDS), a federated sector-wide logistics data-sharing infrastructure for the Dutch logistics industry, and run pilot projects with industrial partners.

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 demonstrate the technological readiness of data spaces to the industry.

The **ICCOS project (2019)** aims to design a logistics data space 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]. Prototypical AIAs are developed and evaluated with industry partners [28]. Current work aims to incorporate the iSHARE trust framework [29] and searches alignment with the IDS RAM. Furthermore, 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 (2020)** 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 to 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. Current research focuses on formulating the digital twin architecture, the explorative

competency questions it could help companies respond to, and developing tools for implementation and deployment.

The **DASLOGIS project (2021)** addresses inter-data space connectivity issues, as the flow of sensitive data crosscuts 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 DASLOGIS 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. Currently, the project has not provided proof-of-concept implementation.

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 both international and national level, semantic standards are developed. Standardization bodies like SUTC [35] and DCSA [36] establish and promote standards for the logistics industry.

4. Lessons learned

Based on the results and findings, Figure 1 visualizes policymaking, research projects, and development initiatives, on EU level and national level in the Netherlands.

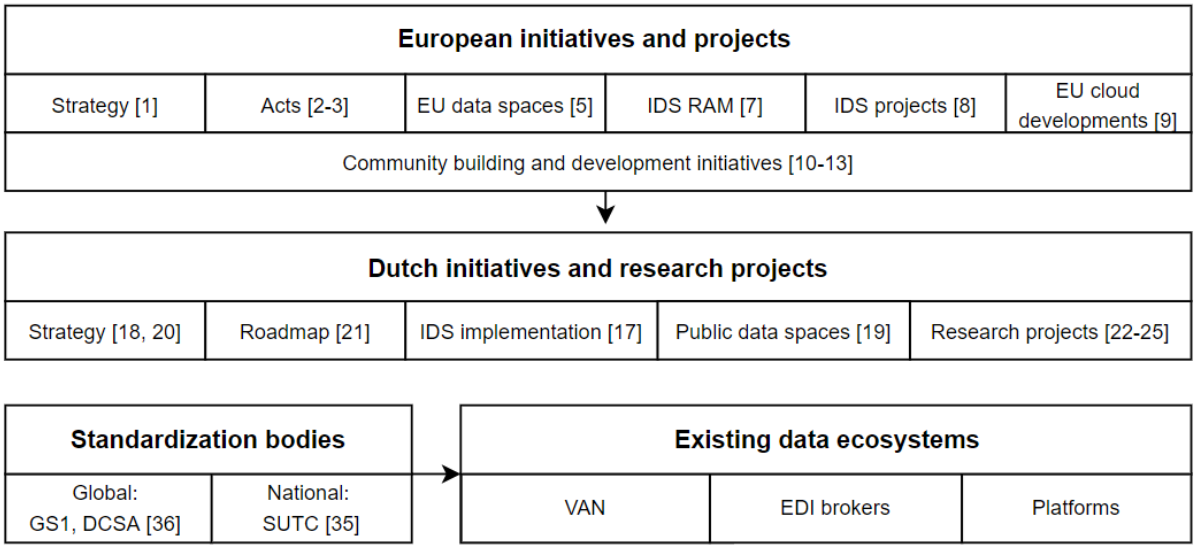

Figure 1: Overview of European and Dutch initiatives and projects for data spaces.

The data space level playing field is rapidly changing on various levels. Most initiatives focus on policymaking, reference architectures, infrastructure, and governance. More attention should be 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, which should be explored and evaluated.

The plans to realize the sector-wide logistics 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 [37]. SME enablement 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. More specifically, no neutral party in the current system regime fulfills the clearinghouse role as defined by IDS.

5. Conclusion and future work

This discussion paper provided an overview of completed and current research endeavors related to logistics data spaces and searched alignment with the European data spaces developments.

The roadmap [21] gives direction for research and the initial development of a sector-wide data-sharing infrastructure for the Dutch logistics industry, but does not prescribe the necessary system change and long-term vision. This falls outside the scope of individual research projects and requires strategic support of the government, branch organizations, and standardization bodies. The development and large-scale deployment of logistics data spaces and a federated sector-wide logistics data-sharing infrastructure will require a long-term commitment (like the DTS). The roadmap needs to be extended.

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 SME consultations, together with branch organizations and researchers, regarding data sharing challenges and needs for implementation support; and (3) involve SUTC to promote the IDS standard and integrate existing 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 [8].

There are also research challenges and opportunities to address in future work, like gaps to be explored in (1) cross-sector data space interoperability (e.g., between SCSN and DLDS); (2) semantic interoperability of OTM and DCSA with GS1 standards, and (3) 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 an organization that can fulfill the role of clearing house in the Dutch logistics industry; and (4) leveraging capabilities and resources required for the development of logistics data spaces, e.g., IT and legal expertise.

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