AN INDUSTRY PLATFORM FOR DATA-DRIVEN LOGISTICS IN SMALL AND MEDIUM-SIZED ENTERPRISES

JEAN PAUL SEBASTIAN PIEST

“Knowledge must flow”

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PDEng thesis

An Industry Platform for Data-driven Logistics in Small and Medium-sized Enterprises

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by

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Abstract

Whereas real-time data nowadays is widely available and advanced data-driven approaches are emerging, organizations in the Dutch logistics industry, in particular Small and Medium-sized Enterprises (SMEs), lack the expertise to effectively identify which data-driven logistics applications are suitable and which tools to use to subsequently adopt these approaches in their daily operations. Based on the design science research methodology, this PDEng thesis presents the results and findings related to the research, design, development, demonstration, and implementation of an industry platform for data-driven logistics based on the Open Trip Model (OTM), to create re-usable data-driven applications for SMEs in the Dutch logistics industry. The core contribution of this PDEng thesis is the architecture for an industry platform for data-driven logistics that is tailored to the need of SMEs. The industry platform architecture consists of the following components and interfaces: 1) a graphical user interface for SMEs to access platform services, 2) APIs for data exchange based on the OTM, 3) an OTM compliant database for unified storage of logistics data, 4) an agent repository for re-usable data-driven applications and development tool for testing various algorithms, and 5) a scalable infrastructure for provisioning computing resources to deploy, run, and monitor agents. The industry platform architecture is complemented with a design canvas, workshop materials, implementation guidelines, and adoption framework to transfer the industry platform functionality to SMEs as part of a learning community. The industry platform concept is verified by means of an expert panel consultation, deployed for testing, and its use is demonstrated and validated using case-based research at a Dutch logistics services provider. The results and findings are disseminated to the scientific community via peer-reviewed publications and presentations during international conferences and workshops. Additionally, the results and findings are communicated to the logistics community via professional reports, presentations and workshops at industry events, and articles in the media. The instantiated industry platform and case study support awareness building of potential data-driven logistics applications in the logistics industry and lowering the barriers for SMEs to start adopting data-driven approaches in their daily practice. The industry platform provides a foundation for further empirical research and a rich testbed for experimental development of data-driven logistics approaches in logistics. Future research will focus on comparing modern, traditional and hybrid data-driven approaches, experimenting with federated learning among SMEs, and incorporating data sharing concepts as part of the federated data sharing infrastructure that is currently being developed for the Dutch logistics industry.

Keywords: industry platform, data-driven logistics, learning community, small and medium sized enterprises, SMEs, open trip model, OTM

Preface

After working more than 10 years in the industry and advancing my knowledge via part-time studies, I decided to pursue the academic career path. Although I was already involved in several research projects as an industry partner, this was quite a U-turn in my former career in IT consultancy and software services. Together with Prof. Dr. Maria Eugenia Iacob, I started writing grant proposals and got funding awarded to conduct industrial and experimental research about artificial intelligence and intelligence amplification in the logistics industry. Initially my aim was to start with an industrial PhD trajectory, but this was not feasible given the 2-year funding. Instead, the Professional Doctorate in Engineering (PDEng)[1], which is a certified academic degree obtained upon completion of the 120 EC post-master Technological Designer programme, offered me the opportunity to get into academia while keeping close collaboration with industry. The differences between a PDEng and PhD are visualized in **Figure 1**. I decided to go for it and find a way to obtain funding for the industrial PhD along the way. Before we dive into the contents of the research, I present a timeline of **My journey** in **Table 1** and **Reader's guide**.

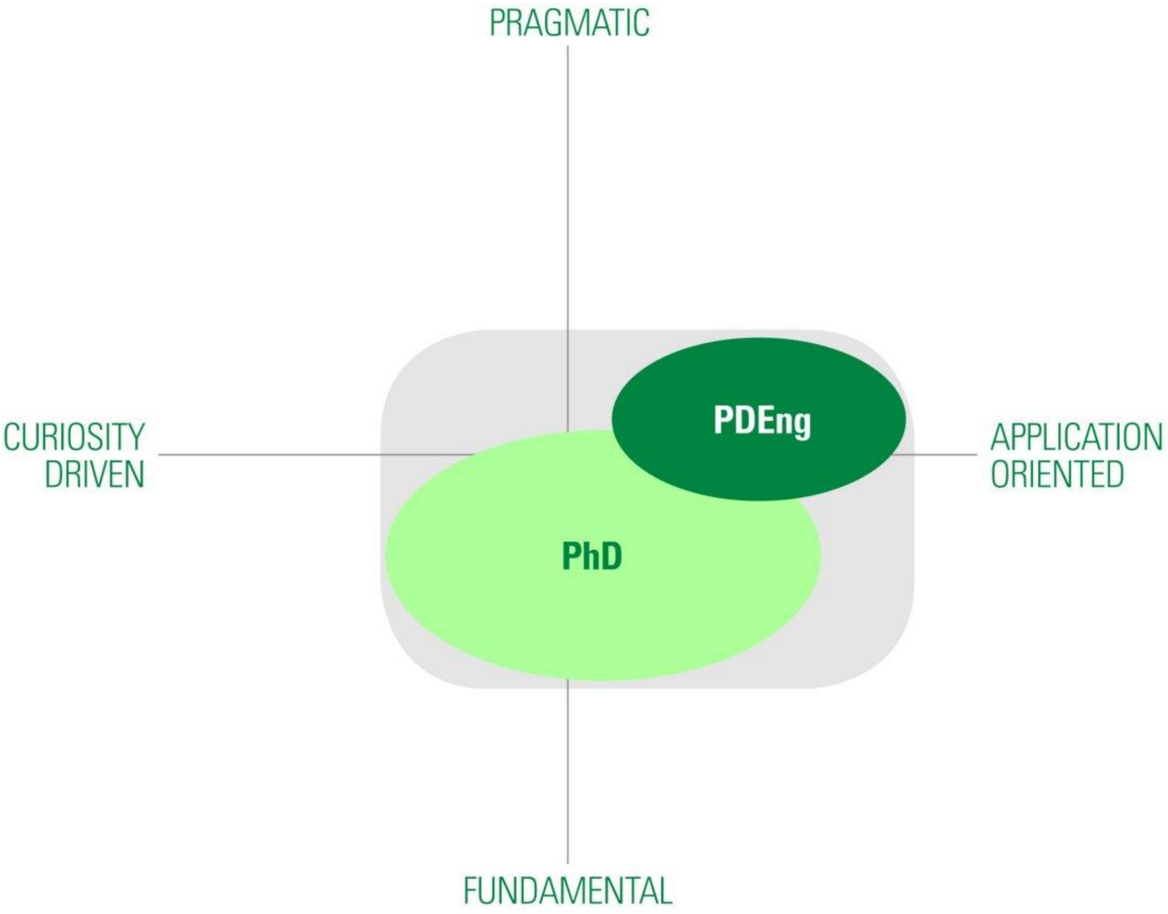

Figure 1: Difference between PDEng and PhD.

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[1] What's PDEng? https://www.utwente.nl/en/education/tgs/prospective-candidates/pdeng/what-is-pdeng/

My journey

Year	Month	Project				Activity, event, or milestone	Related output (Appendix A)
		ALM	ICCOS	CLiCKS	ReAL		
2018	April	🟩				Start TKI DINALOG project Autonomous Logistics Miners for Small- and Medium-sized Business (ALM)	Project page at dinalog.nl
		🟩				1st ALM consortium meeting at Albert Heijn	
	September					Appointment as Researcher at the University of Twente	
						Opening academic year: building bridges	
		🟩				2nd ALM consortium meeting at CAPE Groep	
		🟩				Round table Evofenedex	Article in Evofenedex magazine
	October	🟩				Presentation intermediate results at ICT & Logistiek	Cover story Logisticx
2019	January	🟩				3rd ALM consortium meeting at Kien Logistics Management	
	April					Intake PDEng programme	
						Intake University Teaching Qualification (UTQ)	
		🟩				VLM workshop ‘Technology in Logistics’ at Evofenedex	
		🟩				VLM workshop ‘Technology in Logistics’ at Combi Terminal Twente	
			🟪			Start TKI DINALOG project Industry 4.0 driven Supply Chain Coordinator for Small and Medium-sized Enterprises (ICCOS)	Project page at dinalog.nl
	May	🟩				4th ALM consortium meeting at Deltago	
			🟪			1st ICCOS consortium meeting at University of Twente	
						PDEng qualifier	Qualifier report
	June	🟩				Annual congress VLM: panel discussion, presentation intermediate results, and design canvas workshop	Design canvas workshop
			🟪			2nd ICCOS consortium meeting at Veenman / Xerox	
	September					Opening academic year: butterfly effect	
	October	🟩	🟪			EDOC Conference Paris, France	Doctoral consortium paper / workshop paper
	December		🟪			3rd ICCOS consortium meeting at University of Twente	
		🟩				Summit Ketenregie	Article on logistiek.nl

Year	Month	Project				Activity, event, or milestone	Related output (Appendix A)
		ALM	ICCOS	CLiCKS	ReAL		
2020	January			🟧		1st CLiCKS consortium meeting at University of Twente	
			🟪			4th ICCOS consortium meeting at University of Twente	Design canvas workshop
	February	🟩				5th ALM consortium meeting at University of Twente	
		🟩	🟪			Teaching cases Albert Heijn, Kien Logistics Management, and Emons	
	March			🟧		2nd CLiCKS consortium meeting at CAPE Groep	
						COVID-19 pandemic: lock-down measures	
				🟧		I-ESA Conference Tarbes, France – Re-scheduled due to COVID-19	2 SIFAI workshop papers
			🟪			Start monthly online ICCOS meetings for requirements gathering via MS Teams	
	April	🟩				End TKI DINALOG ALM project	Public report
	June					End lock-down measures	
	September					Opening Academic Year: UTour (Online)	
			🟪			Design workshop at Emons	IHIET paper
		🟩				Presentation final project report during congress of Topsector Logistiek	Project report / resultatenboek Topsector Logistiek
			🟪	🟧		Presentation whitepaper data sharing infrastructure for logistics	Whitepaper
	October		🟪			Start pilot at Emons with Bullit Digital	
						Second lock-down	
			🟪	🟧		EDOC Conference, online	Demo paper
		🟩				Online lecture and tutorial during Week van Logistiek.nl	Article on Logistiek.nl
	November			🟧		I-ESA Conference, online	2 SIFAI workshop papers
			🟪			Evaluation pilot at Emons	NL AI Coalition use case
	December		🟪			Initial list of requirements	
		🟩				Cases featured in impact report	Impact 4C in de praktijk
2021	January		🟪			Verification of requirements and architecture with consortium partners	TRL 2-3
	February		🟪			Start development of industry platform with design and development team	TRL 3
			🟪			Teaching cases Districon (BigMile) with Emons and 6 other companies	Logistiek.nl blog series
	March		🟪			First release of industry platform, testing with practitioners	TRL 5

Year	**Month**	**Project**				**Activity, event, or milestone**	**Related output (Appendix A)**
		ALM	**ICCOS**	**CLiCKS**	**ReAL**		
2021	March			■		3rd CLiCKS Consortium Meeting	
			■			Launch of Conversation Pieces Series	8 Illustrated Research Posters
	April		■			End TKI DINALOG ICCOS project – Project extended due to COVID pandemic	
			■			ICEIS Conference, online	Position paper + initial experiments (TRL3)
	May		■			Start second iteration platform development and testing with practitioners	TRL 6
	June					End second lock-down	
						Completion UTQ assessment	
	July		■			Second release of industry platform, deployment and testing with end-users	TRL 7
			■		■	Start NWO Accelerator project Reinforcement Learning Platform for Small- and Medium-sized Enterprises (ReAL)	
	September					Opening academic year: BlendUT	
		■				Nomination Dutch BI & Data Science Award	
				■		4th CLiCKS Consortium Meeting at University of Twente / Hybrid	
			■		■	Start third iteration of industry platform development	TRL 8
			■		■	1st DALI Workshop	IHIET paper
	October		■		■	Third release of industry platform, deployment and testing with end-users	TRL 8
			■	■		Master course Enterprise Architecture: Symposium with IDS project presentations	
			■		■	2nd DALI Workshop	IHIET paper
			■	■	■	International EDOC Conference, online	Research paper
			■		■	Start developing dynamic planning and refuelling agent at Emons	TRL 7-8
2022	January		■		■	Blended course AI Design Canvas implemented with Deltago	
					■	Start as educational designer at NL AI Coalition to design the AI Awareness course for Logistics	
	February		■		■	Start implementing dynamic planning and refuelling agent at Emons	TRL 8-9
			■			Evaluation ICCOS project	
			■		■	3rd DALI Workshop	IHIET paper
			■		■	Intermediate evaluation project at Emons	
	March		■	■		International I-ESA Conference 2022, Valencia, Spain	EI4IDS workshop paper

Table 1: Overview of my journey.

Reader's guide

The main focus of the PDEng is on multi-disciplinary technological design and advancing the Technological Readiness Level (TRL). This PDEng thesis documents the results and findings from design science research, software engineering, action design research, and incorporates materials from PDEng courses regarding systems engineering. Because this PDEng thesis is written for a broad audience and stakeholders have different interests, this reader's guide provides a visual overview of the structure and coverage of this PDEng thesis, as shown in **Figure 2** below.

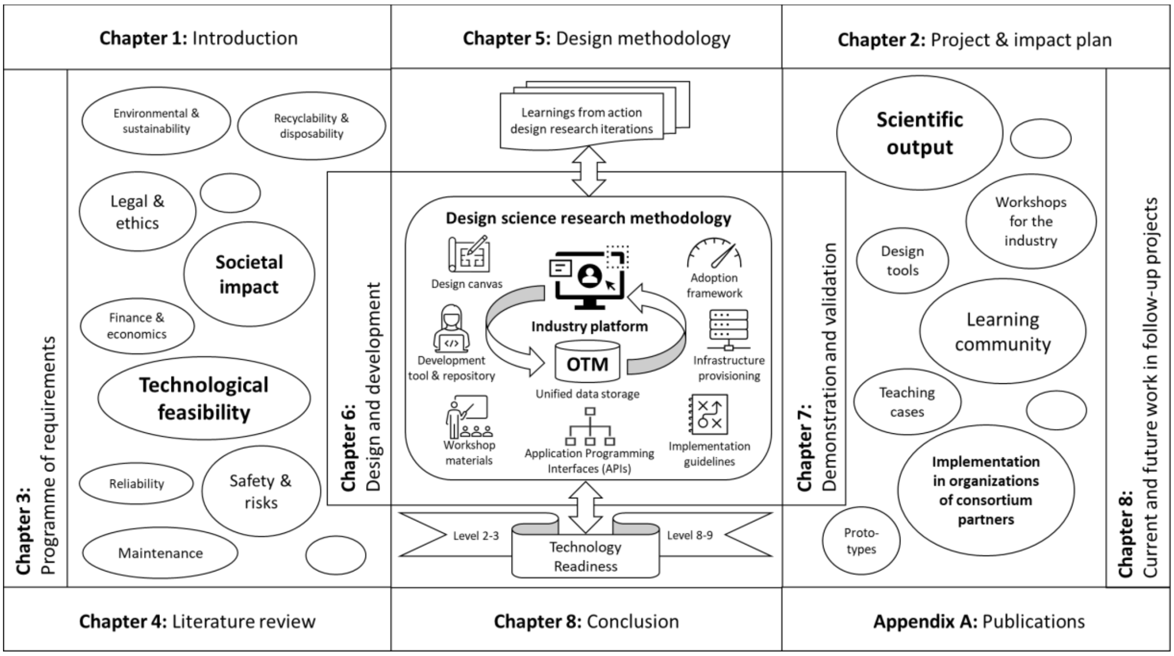

Figure 2: Visual overview of the structure and coverage of this PDEng thesis.

This PDEng thesis is structured based on the template provided by the PDEng programme:

1. **Introduction** of the background, related work, motivation, and structure;
2. **Design project** background and objectives from the temporal project environment;
3. **Programme of requirements** emphasizing multidisciplinary design aspects;
4. **Literature review** discussing relevant theoretical aspects and related work;
5. **Design methodology** presenting the design approach, phases, and methods used;
6. **Design and development** reflecting the process from concept creation to realization;
7. **Demonstration and validation** of the realized industry platform and related artefacts;
8. **Conclusion and future work** based on the main results and findings.

Each chapter starts with a brief introduction of the structure and coverage and ends with a summary of the results and findings. Visual references are incorporated throughout the PDEng thesis to connect the contents to the steps of the design methodologies used and developed artefacts.

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List of abbreviations

2PL	Second-party Logistics
3PL	Third-party Logistics
4C	Cross Chain Collaboration Centre
AI	Artificial Intelligence
AIS	Automatic Identification System
ADR	Action Design Research
AGV	Automated Guided Vehicle
ALM	Autonomous Logistics Miners for small and medium-sized businesses
API	Application Programming Interface
APS	Advanced Planning System
BI	Business Intelligence
BIE	Building, Intervention and Evaluation
BMS	Behavioural, Management and Social sciences
CAPEX	Capital Expenditures
CBS	Centraal Bureau voor Statistiek
CHOOSE	Control, Holistic Overview, Objectives, Suitable for target audiences Enterprise
CLDM	Canonical Logistics Data Model
CLiCKS	Connecting Logistics interfaces Connectors Knowledge and Standards
CO_2	Carbon Dioxide
CPS	Cyber Physical Systems
CRISP-DM	Cross Reference Industry Standard Process for Data Mining
CRUD	Create, Read, Update, Delete
DALI	DAta science voor Logistieke Innovatie
DEFLOG	Data Exchange Facility LOGistics
DINALOG	Dutch Institute for National Advance LOGistics
DL	Deep Learning
DMS	Document Management System
DSRM	Design Science Research Methodology
EAN	European Article Number
ECOGRAI	Acronym (in French) in which ECO refers to Economy and GRAI to Groupe de Recherche en Automatisation Intégrée (Research Group for Integrated Automation)
eCMR	Electronic version of Convention relative au contrat de transport international de Marchandises par Route (in short, the CMR convention)

EDI	Electronic Data Interchange
EDOC	Enterprise Distributed Object Computing
ER	Entity Relationship
ERP	Enterprise Resource Planning
ETA	Estimated Time of Arrival
ETL	Extract, Transform, Load
FAIR	Findable, Accessible, Interoperable, Re-usable
FL	Federated Learning
FMS	Fleet Management System
GDPR	General Data Protecting Regulation
GPS	Global Positioning System
GUI	Graphical User Interface
I4.0	Industry 4.0
IA	Intelligence Amplification
IPR	Intellectual Property Rights
ICCOS	Industry 4.0 driven supply Chain COordination for SMEs
ICEIS	International Conference on Enterprise Information Systems
IDS	International Data Spaces
IoT	Internet of Things
IT	Information Technology
iPaaS	integration Platform as a Service
iSHARE	Agreement framework for identification, authentication, and authorization
KDD	Knowledge Discovery in Data
KPI	Key Performance Indicator
LCB	Logistics Community Brabant
LMS	Learning Management System
LSP	Logistics Service Provider
ML	Machine Learning
OPEX	Operating Expenditures
OR	Operations Research
OTE	Overall Transport Effectiveness
OTIF	On Time In Full
OTM	Open Trip Model
PhD	Doctor of Philosophy
PDEng	Professional Doctorate in Engineering

R&D	Research and Development
RDF	Resource Description Framework
RFID	Radio Frequency Identification
ReAL	Reinforcement LeArning platform for Logistics
RL	Reinforcement Learning
ROI	Return on Investment
SEMMA	Sample, Explore, Modify, Model and Assess
SCM	Safety Cube Method
SMEs	Small and Medium-sized Enterprises
SUTC	Stichting Uniforme Transport Code
TEI	Total Economic Impact
TKI	Topconsortia for Knowlegde and Innovation
TLN	Transport Logistics Nederland
TMS	Transport Management System
TPM	Technical Performance Measure
TRL	Technology Readiness Level
UI/UX	User Interface / User Experience
UTQ	University Teaching Qualification
VLM	Vereniging Logistiek Management
VRP	Vehicle Routing Problem
WMS	Warehouse Management System
WP	Work Package

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INTRODUCTION

1 Introduction

This first chapter introduces the research context and problem statement that resulted in this PDEng thesis. **Section 1.1** establishes the research context. **Section 1.2** narrows down the problem statement and the motivation for this research. **Section 1.3** presents the research design, including research questions, and the methodological approach undertaken. **Section 1.4** concludes this chapter by providing an overview of the structure and coverage of the PDEng thesis. This chapter is an extension and synthesis of published articles as stated in the **Declaration**[2].

1.1 Context and background

This section establishes the research context by introducing the main research themes and topics.

Subsection 1.1.1 summarizes related work regarding Industry 4.0	**Step 1 of DSRM**
Subsection 1.1.2 describes the state of the industry regarding data use	Problem identification
Subsection 1.1.3 discusses the movement towards data-driven logistics	
Subsection 1.1.4 highlights prior research regarding intelligence amplification	

1.1.1 Industry 4.0.

As part of the fourth industrial revolution, also referred to as Industry 4.0 (I4.0), advanced manufacturing or smart industry in large scale development programmes, technological developments with respect to automation and data exchange are emerging. So-called Cyber Physical Systems (CPS) connect machinery, robots, appliances, and potentially any other object, both physically and virtually, to the internet and enable situational awareness by means of sensors and actuators. Because these CPS are equipped with more and more sensors and actuators, they will generate increasingly larger datasets and real-time data streams. Latest advances in Artificial Intelligence (AI), specifically the branches of Machine Learning (ML) and Deep Learning (DL), together with the possibilities offered by CPSs, provide the technological foundation to design intelligent, highly automated production- and transportation systems. The technological advancements related to I4.0 also provide new opportunities for new business development, innovation and realizing competitive advantages. However, the adoption of these emerging I4.0 technologies is a challenging and complex process that assumes the presence of specific expertise to manage and process the data originating from CPSs and its various sources. Furthermore, organizations need to invest in cloud computing, big data analytics tools, industrial robots and/or Internet of Things (IoT) devices to

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[2] **Section 1.1, 1.2, and 1.3** contain parts of the doctoral consortium paper (Piest, 2019) and research paper (Piest et. al., 2021). Additional background materials are incorporated in **Subsection 1.1.2** based on two complementary industry surveys. Furthermore, the motivation for an industry platform, envisioned contribution, and relevance for the Topsector Logistiek are subsequently added in **Subsection 1.2.2, 1.2.3, and 1.2.4** to extend earlier work.

enable flexible automation. Small and Medium-sized Enterprises (SMEs) typically lack the resources, tools, and expertise to adopt these emerging I4.0 technologies.

1.1.2 Technology and data use in logistics

The transportation and logistics industry heavily relies on technology to handle the enormous volumes of goods and related work- and information flows in an efficient manner. The use of technology and data in logistics is studied widely in both literature and practice. Transportation companies (also referred to as 2PL) and Logistics Service Providers (LSP, or third-party logistics 3PL) have access to real-time data from on-board computers in trucks and trackers in trailers via (mobile) communication networks such as the Global Positioning System (GPS). Vessels are equipped with Automatic Identification Systems (AIS) and real-time data are made available via logistics information platform such as MarineTraffic[3]. Similarly, data are made available for planes via platforms such as Flightradar24[4]. At the product level, barcodes are widely used for the identification of products and exchange of data for efficient and appropriate handling. Additionally, Radio Frequency Identification (RFID) tags and IoT sensors can be attached to products and (returnable) load carriers to allow real-time monitoring of the position, movement, and condition of goods to be transported. Specialized information systems are used to capture, store, and process data and manage operational processes in warehouses, transportation of goods, and related logistics services. Additionally, various open data sources can be accessed to further enrich the available logistics data with real-time traffic information, localized weather conditions, and network master data. Thus, logistics data are widely available, both internally and externally.

Despite the availability of real-time data, an industry survey among 260 organizations in the Dutch logistics industry in 2018 indicates a fairly limited usage of real-time data and a lack of adoption of modern I4.0 technologies, in particular by SMEs (InfoResult, 2018). More specifically, the results of the survey show that 23% of the respondents utilize real-time data for decision-making, 44% use historical data to make decisions, and 19% use available data to explain the past. The remaining respondents do not use data for decision-making. Excel is the main application that is used, followed by Enterprise Resource Planning (ERP) systems, Warehouse Management System (WMS), systems provided by the LSP, systems for route planning, demand planning, and Access databases. Internal data are the main data source for decision-making (63%) and the use of external data from supply chain partners (23%) and market (5%) is limited. On average respondents rate the state of digitalization with a 6.1 out of 10. Investment decisions regarding new technology are made by

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[3] https://www.marinetraffic.com/

[4] https://www.flightradar24.com/

higher management. 67% of the shippers reported in the survey that they are exploring digital platforms. However, the vast majority of the respondents are not looking into I4.0 technological developments, such as big data, cloud computing, IoT and AI.

A second industry survey among 656 organizations in the Dutch logistics industry in 2019 provides a broader and more detailed view regarding organization's state of digitalization and data use (Evofenedex, TLN and Beurtvaartadres, 2019). The survey contributes to better understanding of the information systems used and the level of systems integration and data sharing in supply chains. Overall, 96% of the respondents uses Office, followed by systems for finance (90%), navigation (72%), human resources (63%), Transport Management (TMS) (59%), Fleet Management (FMS) (54%), Advanced Planning and Scheduling (APS) (36%) and WMS (32%). This survey reveals that 38% of the respondents use business reporting software. Contrasting the survey of 2018, only 20% of the respondents use ERP. 13% of the respondents use a Control Tower Platform. The survey illustrates the presence of systems integrations and shows that the 84,2% of data exchanging occurs via unstructured communication (e.g., email, phone, or fax), 33,7% via Electronic Data Interchange (EDI), 33,5% via external developed portals or applications and 21,5% via internal developed portals or applications. The survey reveals differences between the type and size of organizations, asset-based organizations versus non-asset-based organizations (e.g., expediters, forwarders, and platforms) and in-house IT capabilities versus outsourcing. The main perceived barriers are high costs of automation, time and internal resources required for implementation, complexity of implementation, complexity of systems integration, knowledge, skills, and attitudes of involved staff regarding automation, and lack of management support. The average rate of the state of digitalization is not measured in this survey. Overall, there is consensus among the respondents regarding the importance and need for digitalization. Decisions are made by management. Surprisingly, IT plays a marginal role in decision-making. When it comes to technological developments and innovation, there is a clear 'wait and see' attitude and tendency to adopt proven technology. Tangible applications for digitalization of freight documents and electronic invoicing are adopted, but modern technologies such as AI, IoT and blockchain are in an early stage of adoption.

More recently, a third industry survey among 206 organizations in the Dutch logistics industry in 2021 provides additional insights (InfoResult, 2021). In line with the 2018 industry survey, Excel (65%) and ERP (54%) are identified as the main applications. The use of information systems is further detailed with analytical software (21%) and middleware (19%). Roughly 25% of the respondents has access to the desired internal and external data. 53% of the respondents has limited access to desired data. 18% does not have access to the desired data. Compared to the survey in 2018, this survey shows increased data use for reporting results (75%), support decision-making (66%), identify deviations and exceptions (64%), analyse and improve performance (62%), predict and optimize performance (47%), and improve the supply chain (45%). 10% of the respondents, especially SMEs are not using data. The majority of respondents are sharing data with logistics partners (51%), customers (48%), suppliers (40%), the Central Bureau for Statistics (CBS) (28%), governmental organizations (23%), and platforms (13%). 25% of the respondents are not sharing data. 47% of the respondents use industry standards for identification of locations and products, mostly GS1 standards (e.g., barcodes, GLN- and EAN codes). Despite the increased level of data sharing, 61% of respondents report the need for manual (re-)entry of data for logistics (36%), customers (30%), and finance (19%). 56% of the respondents reports using so-called shadow IT, mainly to support transport related operations (25%). The average rating of the state of digitalization is 6.9 out of 10. The survey shows that the digital mindset is increasing, as well as interest and investments in modern technologies. Decisions are made by higher management, especially in SMEs. In larger organizations management teams make the decisions. Training, management support, and development of a clear vision and plan for digitalization are considered main drivers for digitalization. Surprisingly, financial incentives are considered of less importance. Limited time as a result of the focus on daily operations is the main barrier, followed by costs, and lack of qualified personnel. 77% of the respondents state that they rely on external assistance. In-house knowledge, high costs of outsourcing, and remaining in control are the main reasons not to ask assistance. 68% of the respondents are not familiar with the governmental plans for digitalization. 20% of the respondents have knowledge about the Topsector Logistiek's initiatives and knowledge regarding specific projects (e.g., Open Trip Model (OTM)[5], iSHARE[6]) varies between 4-16% of the respondents. This indicates a fairly limited awareness of Topsector Logistiek initiatives and projects.

Although the three industry surveys stand on their own, they indicate a serious gap between the scientific knowledge base, available technology, and their transfer to and use in practice by organizations, especially SMEs. The industry surveys provide detailed insight regarding the presence and use of information systems, current state of digitalization, and data use by different types and sizes of organizations in the Dutch logistics industry. The industry surveys also illustrate the heterogenous character of the Dutch logistics industry, large variety of IT suppliers, and limited adoption of modern technologies. Taken together, a slight improvement regarding data use can be identified when comparing the results and findings of the three industry surveys. Caution is required regarding generalization because of the limited sample size of the three industry surveys.

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[5] https://www.opentripmodel.org/

[6] https://www.ishareworks.org/en

1.1.3 Towards data-driven logistics

Based on the emerging I4.0 technologies, especially the advancements in AI, IoT and modern robotics as part of CPSs, the logistics industry has the potential of becoming a data and AI-driven industry. This is already demonstrated in use when looking at the largescale deployment of onboard computers and sensor technology with supporting global communication networks, the use of Automated Guided Vehicles (AGV), intelligent sorting and storage systems and robotized order picking in warehouse facilities, and readily available software for advanced planning and scheduling, optimization, demand forecasting, and capacity planning. The presence and wide availability of real-time (sensor) data, together with the advances made in modern AI, enables computers not only to solve problems based on human instructions, but also solve problems (partly) autonomously. Because of the decreased costs of modern computer power (on edge devices), the availability of large amounts of logistics data, and readily available software to process and analyse big data, AI is becoming increasingly interesting for logistic organizations that can now (partially) automate tasks that currently require human interaction and (some level of) intelligence. According to McKinsey, the digital transformation towards large scale use of AI is beyond the initial stage of infancy, but the majority of its economic and business impact is still expected to come. Large logistics organizations and innovators like DHL, that already deployed several AI applications, believe it will become a strategic imperative for the logistics industry with the potential to "fundamentally extend human efficiency in terms of ... quality, and speed by eliminating mundane and routine work" (Gesing, Peterson and Michelsen, 2018). However, while AI and related technology are maturing, it is crucial to develop a holistic approach to AI and also consider ethical, legal, and societal aspects when designing, developing, and deploying AI applications.

1.1.4 Intelligence amplification

Prior research regarding Intelligence Amplification (IA) has proposed the idea of achieving enhancement of analytic and decision-making capabilities using human-machine symbiosis. The human centric view of IA essentially differs from the traditional AI view. The concept of IA is based on the idea that humans and machines can re-enforce each other’s abilities whilst ensuring human oversight and control, whereas AI aims to design autonomous entities that can mimick cognitive functions and eventually can replace the human intelligence with artificial intelligence systems. Recent IA approaches state that the analytic capabilities equals the sum of human capabilities, of machine capabilities, and of capabilities that are the result of collaboration between human and machine. This way 1 + 1 < 2. The IA framework proposed by Dobrkovic et. al. (2016) takes a decision-making process as a starting point, decomposes its tasks, and assigns tasks to the human, machine or to human and machine (symbiosis). Based on this systematic task decomposition, intelligent agents can be designed and implemented to the tasks assigned to them. These intelligent agents utilize machine intelligence and AI, but the operator remains in control and in the loop for human oversight. Experiments using serious gaming show promising results as far as the decision-making performance of the hybrid solution is concerned, but IA needs further empirical validation. The concept and application of IA will be further examined in a research project, which is the basis for this PDEng thesis and further introduced in **Chapter 2**, and transferred to the operational context of SMEs in the logistics industry for empirical research.

1.2 Motivation

This section narrows down the problem statement and motivation for this research.

Subsection 1.2.1 describes the problem statement and solution objectives	**Step 1 and 2 of DSRM**
Subsection 1.2.2 positions the ideas for an industry platform for SMEs	Problem identification
Subsection 1.2.3 outlines the envisioned contribution to science and practice	Solution objectives
Subsection 1.2.4 discusses the relevance for the Topsector Logistiek	

1.2.1 Problem statement and objectives

This research is practice inspired and problem driven. The core problem that is addressed in this research is the limited usage of logistic data by SMEs in the Dutch logistics industry, especially real-time data originating from I4.0 technologies (e.g., smart IoT devices and sensors). SMEs represent 99% of the European enterprises and are the backbone of the economy (European Commission, 2022). Advancing data use is expected to contribute to increasing competitiveness. In particular SMEs face difficulties and lack expertise, tools, and resources. Based on the context and background in **Section 1.1**, several barriers and challenges are identified and visualized in **Figure 3**.

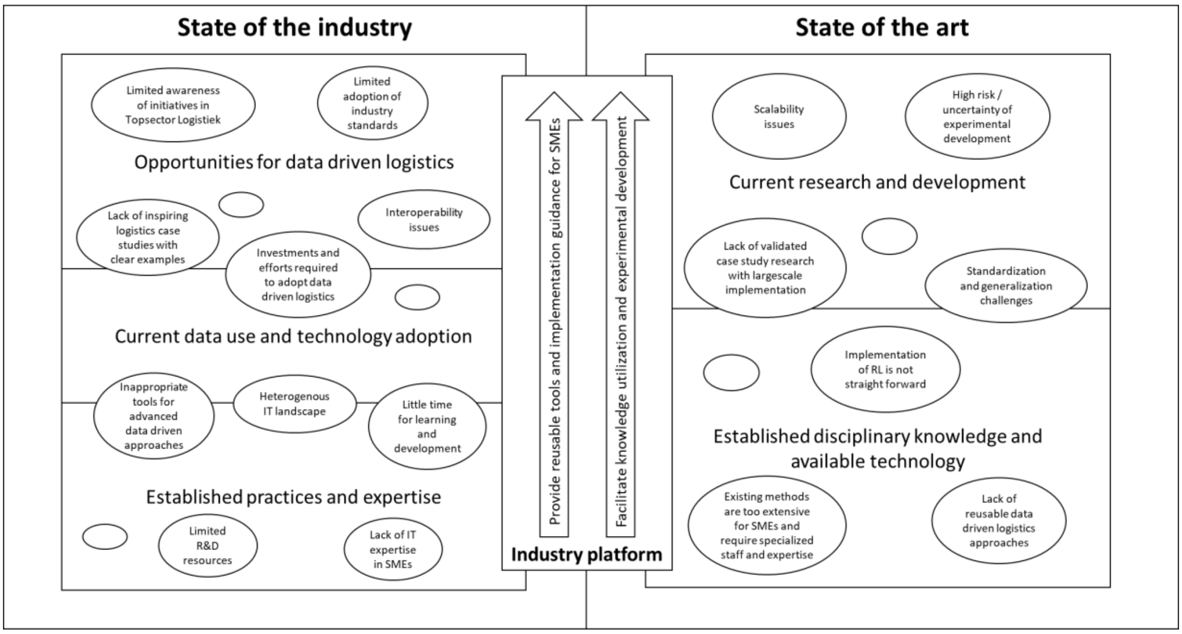

Figure 3: Problem identification and positioning of the industry platform.

Although the importance of data-driven logistics for competitiveness and potential use of AI for logistics is evident, SMEs make limited use of their data. In line with **Figure 3**, this research aims to contribute to both advancing the state of the art and state of industry and bridge (parts of) the gap between science and industry by developing an industry platform that offers re-usable tools and implementation guidance for SMEs and facilitates knowledge utilization and experimental development. Therefore, the following challenges are addressed:

1) **State of the art:** Reinforcement Learning (RL) applications are in the phase of (academic lab) experiments and have scalability issues. Most applications are theoretical or based on serious games and analytical examples, while large scale industry implementations are scarce in literature. Furthermore, whereas (un)supervised ML approaches are matured and widely available in software solutions, the implementation of RL is not as straightforward and involves high risks and uncertainty. Standardization and generalization are challenging, and the established disciplinary knowledge base contains limited re-usable data-driven logistics approaches;
2) **State of the industry:** While real-time data and sophisticated data-driven logistics approaches are emerging, logistic organizations, in particular SMEs, lack the expertise and tools to effectively identify which business processes and applications are suitable for data-driven decision-making and which tools to adopt for incorporating these approaches in their daily practice. Furthermore, the IT landscape in the Dutch logistics industry is heterogenous and interoperability issues will rise due to limited use of industry standards. Adopting data-driven logistics approaches involves large investments and requires much efforts to realize. Lastly, there is a lack of inspiring case studies with clear examples and limited awareness regarding initiatives in the Topsector Logistiek.

Inspired by the collective industry approach for technology watch and competitive intelligence through intermediate Research and Development (R&D) centres of Ponis and Christou (2013), the overall objective of the industry platform and supporting guidelines is to stimulate the adoption of data-driven logistics within SMEs as a treatment to the core problem. Considering the challenges above, the main R&D goals are to:

1) Design, develop, test, and implement an industry platform for data-driven logistics, based on the OTM, for SMEs in the logistics industry;
2) Complement the industry platform with implementation guidelines that stimulate adoption throughout SMEs in the context of a learning community.

1.2.2 Developing an industry platform for SMEs

While every organization has access to data, not every company has the required knowledge, competences, and software available to process and analyse data. In particular SMEs have limited resources and experts available internally. In addition, every organization makes use of different systems, data sources, and formats. The main idea that is incorporated in the industry platform is to create a "Swiss army knife for data-driven logistics" that SMEs can use to support operational decision-making. Based on a collective approach and unified data model, standard data analytics techniques are made available for SMEs who do not have much IT expertise or tools in-house. Re-usable algorithms are developed and made available for SMEs as pluggable services of the industry platform, with the goal of making the implementation as simple and efficient as possible, and also providing access to more sophisticated data-driven logistics approaches. The challenge here is to design solutions that can be seamlessly integrated into the operational environment of SMEs, are cost-efficient and easy to use, require minimal effort and external assistance to implement, and deliver accurate results with minimal performance loss and errors. The supporting implementation guidelines should foster adoption and learning on the job in operational environments.

1.2.3 Envisioned contribution for science and industry

The core contribution of this PDEng thesis is the industry platform architecture and the instantiation of its main components and interfaces. To the best of our knowledge no general decision-making platform architecture exists yet that is based on a collective industry approach and embodies the ideas behind the hybrid intelligence paradigm of IA. More specifically, the industry platform that is proposed in this PDEng thesis combines standardized data-driven logistics applications, is based on a unified data model and industry standards to achieve interoperability and support a broad range of logistics decision-making processes in SMEs. Additionally, this PDEng thesis advances the state of the art with new reference architecture models and validated empirical research regarding IA in the logistics industry. As mentioned earlier, the implementation is based on the OTM, which is an open source, flexible data sharing model, that can contribute to standardization of data-driven applications and enhances their interoperability and use in the logistics industry. The industry platform introduced in this PDEng thesis increases the awareness of SMEs about the potential applications of data-driven logistics decision-support as proven by the industry platform's instantiation, validation, and by case study research. Furthermore, the implementation guidelines offer researchers and practitioners a starting point for the development of data-driven logistics applications.

1.2.4 Relevance and contribution to the Topsector Logistiek

The Topsector Logistiek's action agenda for 2021-2023 (Topsector Logistiek, 2019) has a clear focus on scaling up the use of knowledge, tools and results produced in projects, development of tools for SMEs and training programs for regional networks. The industry platform contributes to these goals and the priority theme data-driven logistics, which is aimed at adoption and use of advanced data analytics and modern techniques such as ML and RL, and the cross-cutting human capital theme. On a national level, the research project, that is the basis for this PDEng thesis and further introduced in **Chapter 2**, aims to improve the competitiveness of the Dutch logistics sector by increasing the adoption and usage of advanced real-time data analytics and narrowing the knowledge gap between workforce knowledge about data-driven logistics. More precisely, the industry platform contributes to scaling up the adoption and use of OTM. The OTM is positioned as the semantic standard within the Federated Data Sharing Infrastructure for the Dutch Logistics sector (Bastiaansen et. al., 2020). The roadmap presented in this whitepaper highlights 3 application domains, cities, corridors and/or hubs, and supply chains, and illustrative use cases for transactional data sharing, big data analytics and real-time visibility. Industry use demonstrates how the OTM is/can be used: sharing and optimizing planning, streamlining order handling, connecting board computers to provide real-time track and trace, enriching data with open data of the government as part of the DEFLOG[7] project, and the annual CBS Survey[8]. Utilizing the OTM together with advanced analytics and AI is expected to contribute to improving business performance in SMEs, specifically in terms of cost savings, increased utilization degrees, improved service levels, reduced CO_2 emissions, and less waste. Thus, digitalization can contribute to competitiveness and sustainability. Developing a broader set of inspiring industry examples based on actual implementations contributes to knowledge transfer to SMEs and is expected to stimulate adoption. Additionally, the collective approach aligns with the goals of the Topsector Logistiek to scale up the impact of projects via regional networks and collaborations with branch organizations (e.g., TLN[9], Evofenedex[10]) and standardization organizations (e.g., Stichting Uniforme Transport Code (SUTC)[11]). Furthermore, initiatives such as the iSHARE trust framework agreement, digital freight documents (e.g., TransFollow eCMR[12]), and carbon footprinting (e.g., BigMile[13]) can be connected based on the open and extensible OTM as pluggable services to extend the industry platform based on the envisioned federated data sharing infrastructure for the Dutch logistics industry. This also contributes to alignment with European initiatives such as International Data Spaces (IDS) (Piest, De Alencar Silva and Bukhsh, 2022).

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[7] https://www.deflog.org/
[8] https://www.cbs.nl/nl-nl/deelnemers-enquetes/deelnemers-enquetes/bedrijven/onderzoek/wegvervoer
[9] https://www.tln.nl/about-tln/
[10] https://www.evofenedex.nl/
[11] https://www.sutc.nl/
[12] https://www.sutc.nl/transfollow
[13] https://bigmile.eu/

1.3 Research design

This section presents the research design, including research questions, and design methodology.

Subsection 1.3.1 presents the main research question and sub research questions

Subsection 1.3.2 contains a synopsis of the research design and methods used

1.3.1 Research questions

Based on the context, background, and motivation, the main research question that this PDEng thesis aims to answer is twofold: *How can SMEs in the Dutch logistics industry make use of their logistics data and utilize intelligent agents based on the concept of IA to increase their operational and decisional performance?* and *How can an industry platform and learning community together contribute to increasing the overall competitiveness of the Dutch logistics industry?*

Sub research questions are derived from the main research questions and aims of the research. **Table 2** presents an overview of the sub research questions, related s(ubs)ections, and publications.

Nr.	Sub research question	S(ubs)ection	Publications
1	Which data sources, canonical data models, and interoperability standards are available for SMEs in the logistics industry?	Subsection 1.1.2; Subsection 3.1.1; Section 4.5; Section 4.8.	Piest, Iacob and Sinderen (2020); Bastiaansen et. al. (2020); Piest, De Alencar Silva and Bukhsh (2022).
2	Which schema matchers are capable of automatic mapping and harmonization of logistics data models with internal data models of SMEs?	Section 4.8; Appendix C8.	Piest et. al. (2020); Piest and Iacob (2020).
3	What are typical usage scenarios in which intelligent agents can support SMEs to increase their operational and decisional performance?	Section 4.8; Section 6.2; Subsection 6.3.2; Subsection 7.3.4; Section 7.4; Appendix C2-7.	Piest et. al. (2021).
4	What are the requirements for the envisioned industry platform and the level of IT knowledge and resources in SMEs?	Section 3.2; Section 4.2; Section 4.3; Section 7.4.	Piest (2019); Piest et. al. (2021).
5	Which adoption strategies, together with the concept of IA, can be applied to increase the usage of logistics data in SMEs?	Subsection 1.2.2; Section 2.6; Section 4.2; Section 6.5; Section 7.5.	Piest (2019); Piest and Iacob (2020); Piest, De Alencar Silva and Bukhsh (2022).

6	Which KPIs support measuring the effects of the industry platform on the operational and decisional performance in SMEs and the overall competitiveness?	Section 4.7; Subsection 6.5.3; Subsection 7.4.3; Subsection 7.4.5.	Cruijssen and 't Hooft (2020).

Table 2: Overview of sub research questions.

A mix of scientific research, design science research, and action design research is applied in this research project to find answers for the main research question and sub research questions.

1.3.2 Research design and methods

The research design consists of an empirical part and an engineering part. **Figure 4** visualizes the research design of the research project and its phases. The empirical part (phase a-c) is aimed at investigating the current state of the art and data usage in SMEs in the logistics industry. The engineering part (phase d-e) is aimed at the design, development of the industry platform and validation in the operational context of SMEs in the Dutch logistics industry. The main focus of the PDEng is conducting industrial research involving multidisciplinary technological design. This PDEng thesis therefore mainly focuses on the engineering part (phase d-e).

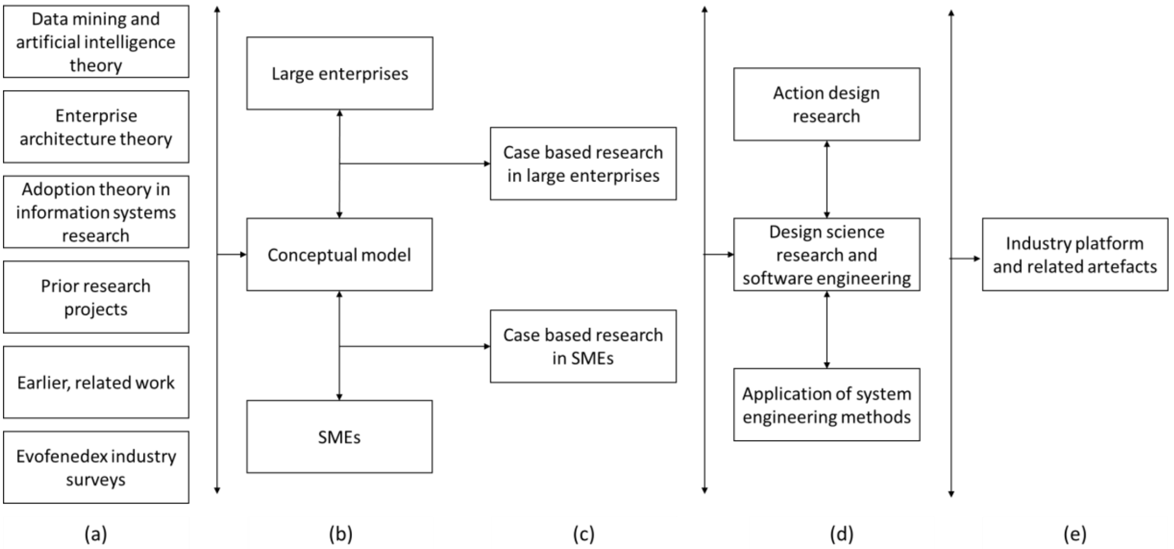

Figure 4: Research design and phases (adapted from Piest, 2019).

The empirical and engineering parts are based on literature from relevant disciplines, results and findings from prior research, earlier and related work, and obtained data from the industry surveys (phase a). A conceptual model is developed to identify the antecedents of data usage in relation to the operational and decisional performance in SMEs (phase b). The conceptual model is analysed from the perspective of SMEs and contrasted with the situation of large enterprises (phase b). Together with the consortium partners of the research project (which includes small-, medium- and large enterprises from the logistics industry), the conceptual model is tested and validated using case-based research (phase c). The results are documented in the project's final report (Piest and Iacob, 2020) and will be discussed in **Chapter 2** and related **Appendices**. The main research methodology is the well-established Design Science Research Methodology (DSRM) for information systems research of Peffers et. al. (2007) (phase d). Action Design Research (ADR) of Sein et. al. (2011) is also applied as it emphasizes on an iterative process that combines observations with interventions from both an organizational and technological perspective (phase d). Furthermore, systems engineering methods are incorporated to detail the development, demonstration, and validation approach and incorporate lifecycle management and societal embedding of the design (phase d). The engineering part builds upon the results of the empirical part and resulted in the industry platform and related artefacts (phase e). The combination of the DSRM with ADR is expected to improve the outcomes of this research project, because it facilitates an incremental development process. Co-creation is expected to contribute to the quality of the designed artefacts and user acceptance. Furthermore, as the industry platform is a multi-sided artefact, designed for a broad group of users in a heterogenous socio-technical environment, several systems engineering approaches are blended in, leveraging theory, models, and tools from the PDEng program. The design methodology is further discussed in **Chapter 5**.

1.4 Structure PDEng thesis

The remainder of this PDEng thesis is structured as follows. **Chapter 2** describes the design project and involved organizations. **Chapter 3** presents the stakeholders and the platform requirements. **Chapter 4** lays out the relevant theoretical foundations for this PDEng thesis and summarizes related and earlier work. **Chapter 5** is concerned with the design methodology and provides a synopsis of the used methods and techniques. **Chapter 6** describes the industry platform architecture and its main components and interfaces. **Chapter 7** demonstrates the industry platform in use and contains the results and insights gained from the validation of the industry platform. **Chapter 8** concludes the PDEng thesis by summarizing the main results and findings, discussing the limitations and implications, explaining the significance for theory and practice, and positioning future work.

DESIGN PROJECT

2 Design project

This chapter describes the design project and involved organizations. **Section 2.1** summarizes the design project in terms of goals, approach, and impact. **Section 2.2** outlines the project plan and work packages. **Section 2.3** presents an overview of the consortium partners. **Section 2.4** contains the work plan and division. **Section 2.5** summarizes how the results are reported, valorised, and disseminated. **Section 2.6** describes the knowledge utilization and impact plan. **Section 2.7** summarizes and concludes the chapter. This chapter is partially based on the project proposal, a published article, and individual course work from the PDEng program.[14]

2.1 Project summary

This PDEng research project is primarily related to the multidisciplinary research project "Autonomous Logistics Miners for Small and Medium-sized Businesses," a 2-year industrial and experimental research project funded by the Top consortium Knowledge and Innovation (TKI) Dutch Institute for National Advanced LOGisics (DINALOG) (TKI DINALOG, 2022a). On a national level, this research contributes to the Dutch logistics industry research agenda by improving the usage of logistics data and the adoption of modern I4.0 technologies by SMEs. The research project aims to increase the competitive power of the Dutch logistics industry by developing intelligent agents that can autonomously perform the most common data analytics and -mining functions and require minimal supervision and IT knowledge from the user. **Figure 5** depicts the envisioned use of intelligent agents in an operational logistics setting.

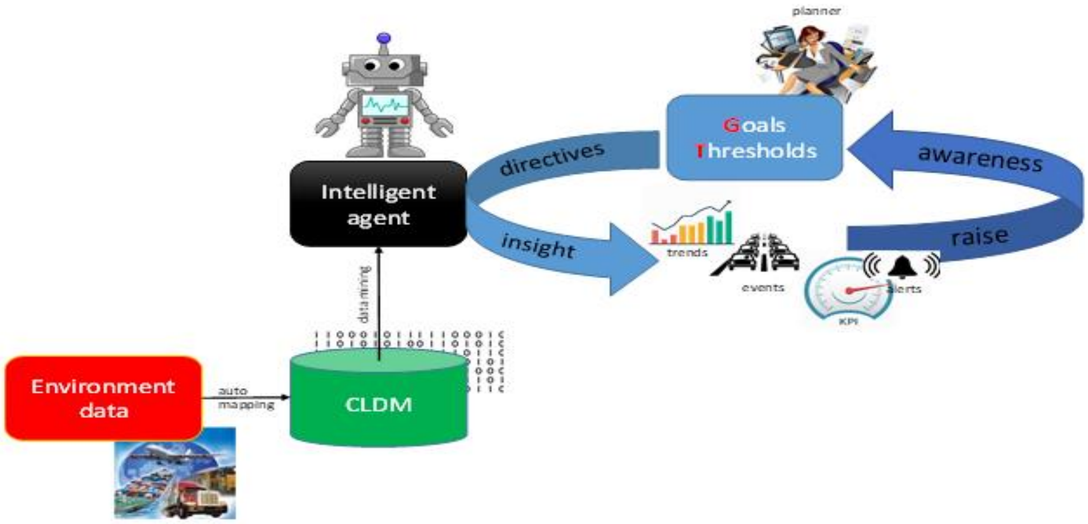

Figure 5: Intelligent agent concept (adapted from Iacob, 2017).

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[14] **Section 2.1, 2.2, 2.4, and 2.6** are based on parts of the project plan (Iacob, 2017). **Section 2.1** is incorporated in the doctoral research paper (Piest, 2019) and adjusted for use in this PDEng thesis. **Section 2.3** is based on individual course work in the PDEng program. **Section 2.5** is added to extend the project introduction and the impact plan in **Section 2.6** is created to extend the approach regarding knowledge utilization.

More specifically, the aim is to increase the use of real-time data, originating from multiple data sources, to support decision-making in operational logistical environments in SMEs. Thus, the research project helps SMEs, that are overwhelmed with data and have limited time, knowledge, and resources to analyse it. The agent's focus is providing insight in the overall performance of supply chains, visualizing trends, detecting patterns in supply and demand, and identifying the critical factors that cause shipment delays and disruptions. Furthermore, the intelligent agent concept aims to create a symbiotic interaction between the human decision maker and intelligent agents, allowing humans to identify conditions of special interest to them and enable the intelligent agents to do the routine work, continuously monitor data streams, and raise awareness to the human operator if events occur. This project and approach are based on the concept of IA, as introduced in **Chapter 1**, and earlier and related work in the TKI DINALOG project SynchromodalIT (TKI DINALOG, 2022b).

2.2 Project plan and work packages

In the project plan, three knowledge-creation work packages are defined: WP1 – Canonical logistics data model, WP2 – Autonomous intelligent agent data analytics, and WP3 – Industrial Application Cases, and two supporting work packages: WP4 – Valorisation and WP5 – Project management. The project overview and descriptions of the 5 work packages are displayed in **Figure 6**.

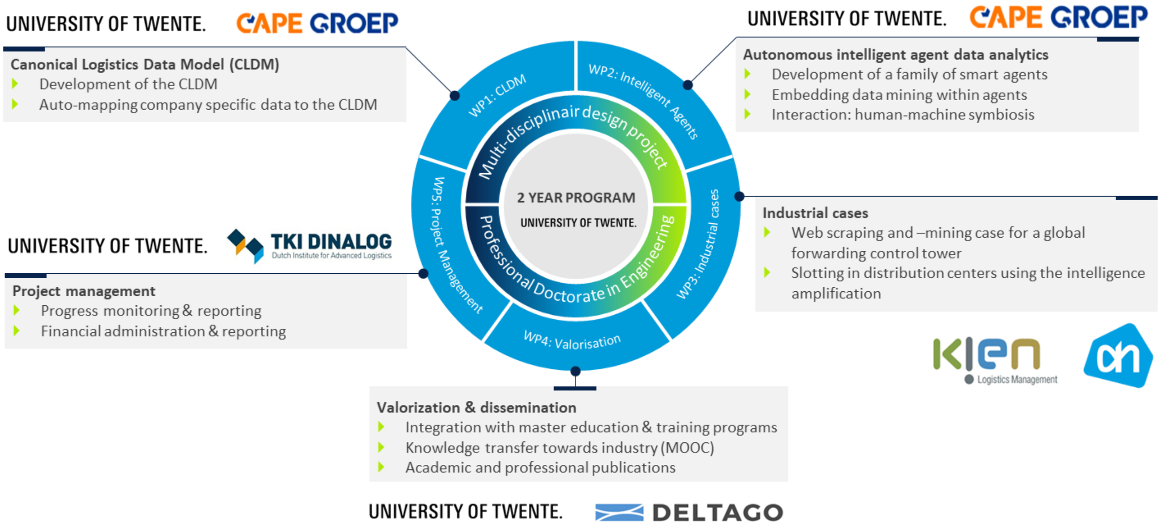


Figure 6: Overview of the PDEng project and work packages (own visualization).

WP1 focuses on identifying a canonical logistics data model that can be shared by all logistics organizations in the Netherlands. This will contain the essential logistics information and form the starting point for the data analytics and mining in WP2. WP2 focuses on low threshold data analytics. Here, the most common data analytics required by majority of the organizations will be identified, and on that basis data mining algorithms are to be embedded within intelligent agents. Finally, these intelligent agents will autonomously mine harmonized logistics data sets, discovering trends and patterns in supply and demand, estimating potential disruptions, and identifying the critical factors that cause shipment delays. Based on the results, the intelligent agents will raise awareness to the human decision makers regarding these factors and highlight the impact on the overall effectiveness and efficiency. WP3 serves both as input and testbed for the knowledge and tools developed in WP1 and WP2. Two industrial cases with different settings are used for industrial research and experimental development: 1) a web scraping and -mining case for a global forwarding control tower, and 2) the case of slotting in distribution centres using the concept of intelligence amplification. WP4 contains activities for valorisation and dissemination of the project results into bachelor and master education, (online) training programs, knowledge transfer to industry and publications. WP5 includes activities to manage the project, monitoring progress, and report results to TKI DINALOG.

2.3 Consortium partners

Table 3 provides an overview of the involved organizations, their role in the project, and the involved stakeholders.

Organization	Role in / relation to project	Stakeholders
TKI DINALOG Dutch Institute for Advanced Logistics	Sponsor. Program management and governing body for public private partnerships. Communication of results to the Topsector Logistiek.	Chairperson program commission, program developer Cross Chain Collaboration Centres (4C), controller, marketing.
UNIVERSITY OF TWENTE.	Researcher and architect. Coordination and execution of the research activities, project management, responsible for the dissemination activities.	Dean, professor, PDEng researcher, bachelor student, master student, project controller.
CAPE GROEP	Developer. Coordination of the implementation and validation activities, responsible for the valorisation process.	CEO, program manager, team lead, consultant, product manager, manager academy.
Albert Heijn	Industry partner and end-user. Definition of one industry case, identification, and formulation of requirements for slotting agent, providing access to retail and logistics data for data mining purposes.	Director logistics support, process manager logistics support, team leader logistics support, logistics support employees.
Klen Logistics Management	Industry partner and end-user. Definition of one industry case, identification, and formulation of requirements for web	Manager global forwarding, global forwarding coordinator,

	scraping agent, providing access to logistics data for data mining purposes.	operational support employees.
DELTAGO	Training partner. Development of training and implementation programs. Dissemination of the results to the logistics industry.	Owner.

Table 3: Overview of the project stakeholders.

Throughout the project, the consortium is significantly expanded. A comprehensive overview of all involved organizations, people and their contributions are included in the **Acknowledgement**.

2.4 Work plan and division

Based on the project plan, the responsibility of work packages is assigned to the involved organizations. **Table 4** provides an overview of work package responsibilities and work division. As a PDEng researcher, I was the principal researcher in the project and responsible for carrying out the research activities of WP1 and WP2 and dissemination activities in WP4. Within WP3, I was closely working together with the consortium partners and contributed to the solution design and architecture. Furthermore, I was supervising multiple Bachelor and Master students that conducted research in WP3 as daily and thesis supervisor. The project management activities in WP5 are the responsibility of the main applicant and project leader Prof. Dr. Maria Eugenia Iacob.

Work package		**Responsibility**	**Work division**
WP1	**1.1**	University of Twente	University of Twente (research), CAPE Groep (development and implementation).
	1.2	University of Twente	University of Twente (research), CAPE Groep (development and implementation).
WP2	**2.1**	University of Twente	University of Twente (research), CAPE Groep (development and implementation).
	2.2	University of Twente	University of Twente (research), CAPE Groep (development and implementation).
	2.3	University of Twente	University of Twente (research), CAPE Groep (development and implementation).
WP3	**3.1**	Kien Logistics Management	University of Twente (research), Kien Logistics Management (requirements, case definition), University of Twente (solution design), CAPE Groep (solution implementation and testing).
	3.2	Albert Heijn	University of Twente (research), Albert Heijn (requirements, case definition), University of Twente

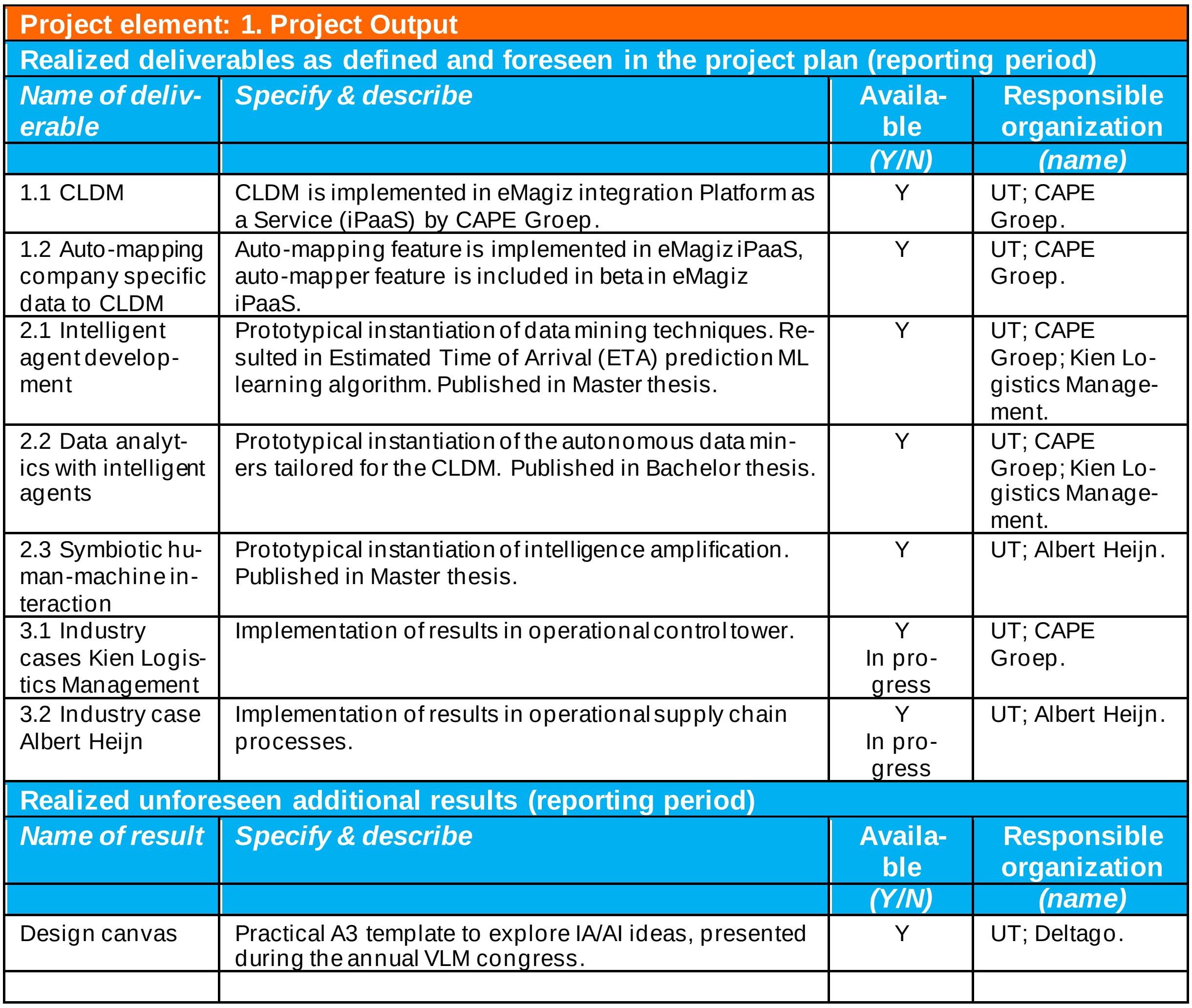
		(solution design, prototyping), Albert Heijn (solution implementation and testing).
WP4	University of Twente	University of Twente (dissemination), CAPE Groep, Kien Logistics Management, Albert Heijn (valorisation) and Deltago (dissemination).
WP5	University of Twente	All (progress monitoring), University of Twente (financial and reporting).

Table 4: Overview of responsibilities and work division.

Together with Prof. Dr. Maria Eugenia Iacob, a project kick-off was organized to clarify the expectations and requirements for the industry partners and 4 consortium meetings were held to manage the project, monitor progress, and share (intermediate) results.

2.5 Reporting, valorisation, and dissemination

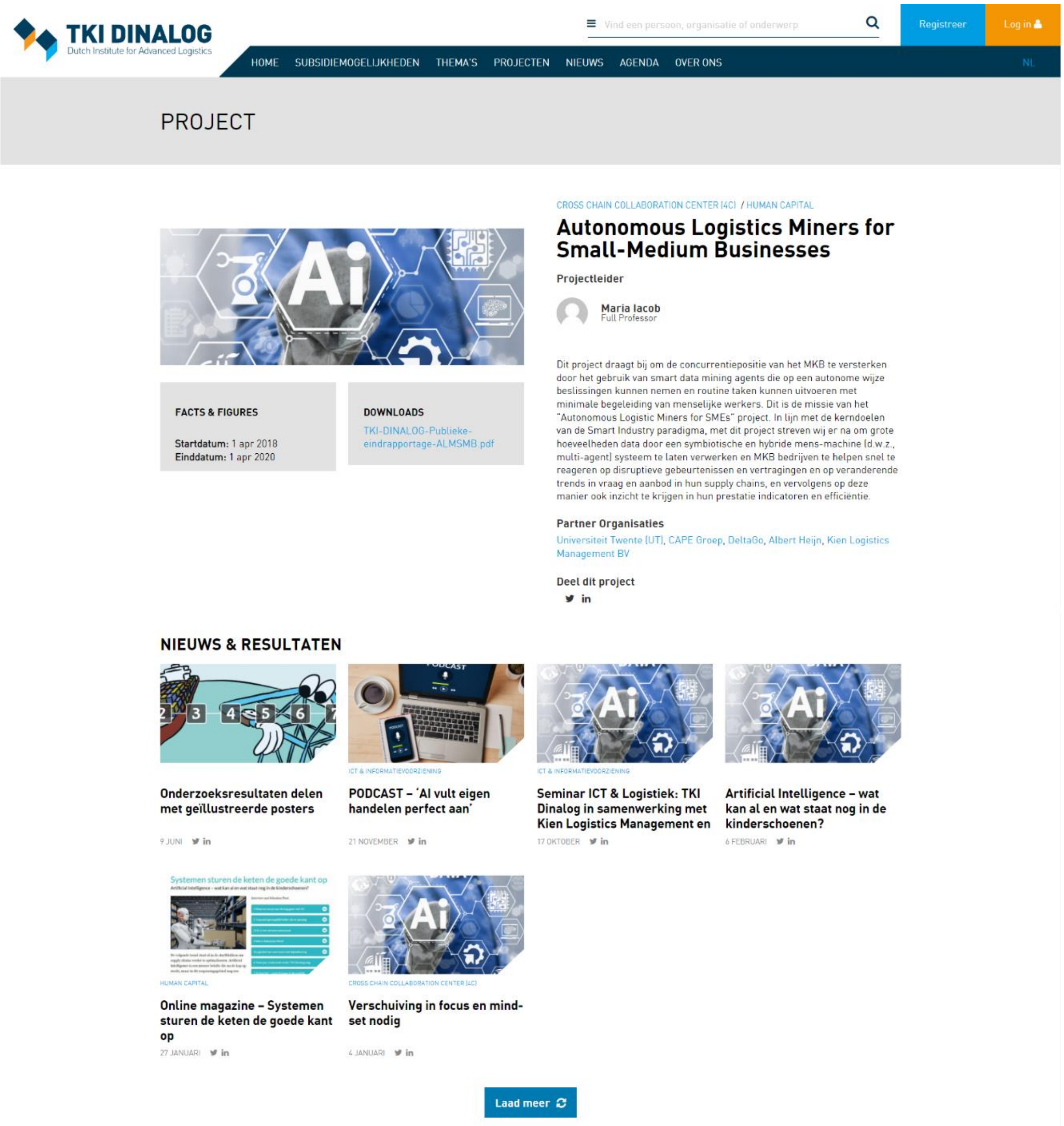
Each 6 months, the project progress and financial situation were reported to TKI DINALOG according to the reporting guide and scorecard shown in **Figure 7**.



Project element: 1. Project Output			
Realized deliverables as defined and foreseen in the project plan (reporting period)			
Name of deliverable	***Specify & describe***	**Available *(Y/N)***	**Responsible organization *(name)***
1.1 CLDM	CLDM is implemented in eMagiz integration Platform as a Service (iPaaS) by CAPE Groep.	Y	UT; CAPE Groep.
1.2 Auto-mapping company specific data to CLDM	Auto-mapping feature is implemented in eMagiz iPaaS, auto-mapper feature is included in beta in eMagiz iPaaS.	Y	UT; CAPE Groep.
2.1 Intelligent agent development	Prototypical instantiation of data mining techniques. Resulted in Estimated Time of Arrival (ETA) prediction ML learning algorithm. Published in Master thesis.	Y	UT; CAPE Groep; Kien Logistics Management.
2.2 Data analytics with intelligent agents	Prototypical instantiation of the autonomous data miners tailored for the CLDM. Published in Bachelor thesis.	Y	UT; CAPE Groep; Kien Logistics Management.
2.3 Symbiotic human-machine interaction	Prototypical instantiation of intelligence amplification. Published in Master thesis.	Y	UT; Albert Heijn.
3.1 Industry cases Kien Logistics Management	Implementation of results in operational control tower.	Y In progress	UT; CAPE Groep.
3.2 Industry case Albert Heijn	Implementation of results in operational supply chain processes.	Y In progress	UT; Albert Heijn.
Realized unforeseen additional results (reporting period)			
Name of result	***Specify & describe***	**Available *(Y/N)***	**Responsible organization *(name)***
Design canvas	Practical A3 template to explore IA/AI ideas, presented during the annual VLM congress.	Y	UT; Deltago.

Figure 7: Illustrative project reporting scorecard.

The final results are documented in the project report and presented during the congress of the Topsector Logistiek (Piest and Iacob, 2020). The research resulted in several academic publications which are presented during international conferences and workshops. Furthermore, the project is featured in the media several times and nominated for the Dutch Business Intelligence (BI) and Data Science Award 2021. An overview of publications and media coverage is included in **Appendix A**. Together with TKI DINALOG, the results were shared via the project web page as shown in **Figure 8**. Based on the data plan template of NWO, which is included **Appendix B**, a project repository is created and maintained.



PROJECT

CROSS CHAIN COLLABORATION CENTER (4C) / HUMAN CAPITAL

Autonomous Logistics Miners for Small-Medium Businesses

Projectleider

Maria Iacob
Full Professor

Dit project draagt bij om de concurrentiepositie van het MKB te versterken door het gebruik van smart data mining agents die op een autonome wijze beslissingen kunnen nemen en routine taken kunnen uitvoeren met minimale begeleiding van menselijke werkers. Dit is de missie van het "Autonomous Logistic Miners for SMEs" project. In lijn met de kerndoelen van de Smart Industry paradigma, met dit project streven wij er na om grote hoeveelheden data door een symbiotische en hybride mens-machine (d.w.z., multi-agent) systeem te laten verwerken en MKB bedrijven te helpen snel te reageren op disruptieve gebeurtenissen en vertragingen en op veranderende trends in vraag en aanbod in hun supply chains, en vervolgens op deze manier ook inzicht te krijgen in hun prestatie indicatoren en efficiëntie.

FACTS & FIGURES

Startdatum: 1 apr 2018
Einddatum: 1 apr 2020

DOWNLOADS

TKI-DINALOG-Publieke-eindrapportage-ALMSMB.pdf

Partner Organisaties

Universiteit Twente (UT), CAPE Groep, DeltaGo, Albert Heijn, Kien Logistics Management BV

Deel dit project

NIEUWS & RESULTATEN

Onderzoeksresultaten delen met geïllustreerde posters
9 JUNI

ICT & INFORMATIEVOORZIENING
PODCAST – 'AI vult eigen handelen perfect aan'
21 NOVEMBER

ICT & INFORMATIEVOORZIENING
Seminar ICT & Logistiek: TKI Dinalog in samenwerking met Kien Logistics Management en
17 OKTOBER

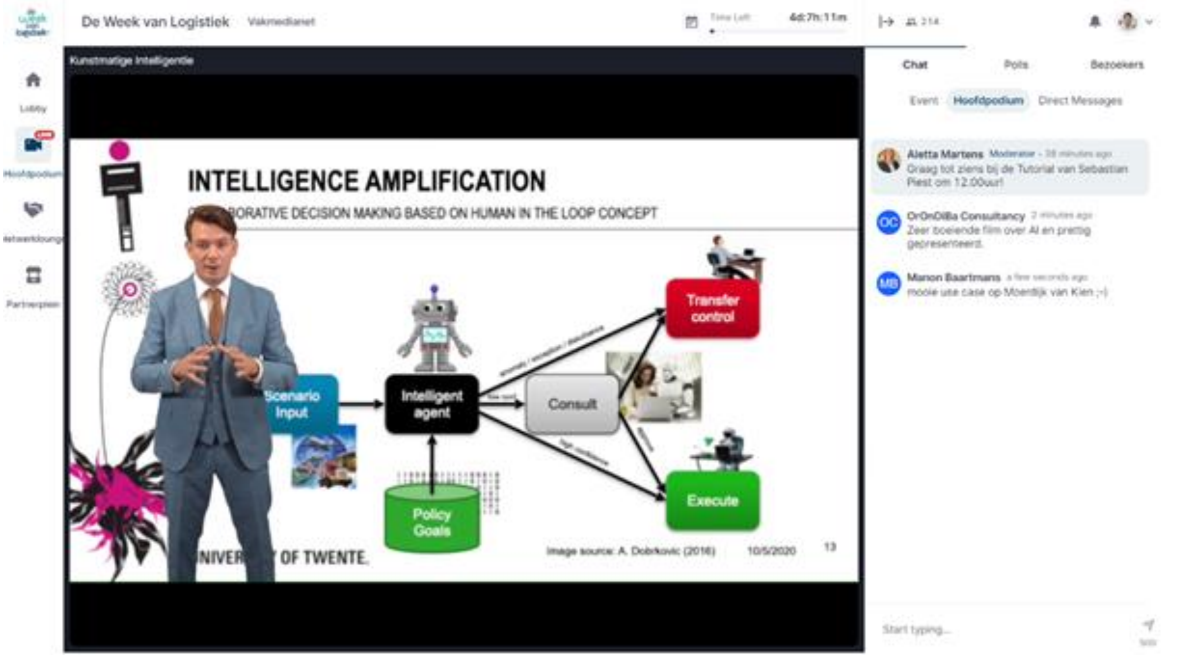
Artificial Intelligence – wat kan al en wat staat nog in de kinderschoenen?
6 FEBRUARI

HUMAN CAPITAL
Online magazine – Systemen sturen de keten de goede kant op
27 JANUARI

CROSS CHAIN COLLABORATION CENTER (4C)
Verschuiving in focus en mind-set nodig
4 JANUARI

Figure 8: Project webpage at Dinalog.nl to share results and news.

Together with involved consortium partners, students and fellow researchers, multiple projects have been completed using design science and action design research and the results are presented during conferences, workshops, and seminars. The projects and interaction with people from different disciplines created a challenging learning environment and realistic conditions for experiments. The industry testbeds at Albert Heijn and Kien Logistics Management with CAPE Groep facilitated rapid prototyping of intelligent agents and software development for implementation and evaluation. The results of the research are incorporated in the Slotting platform at Albert Heijn, Control Tower at Kien Logistics Management via CAPE Groep, and in the eMagiz integration platform. Together with Deltago, case-based research is conducted to study the design and development of intelligence amplification applications from multiple perspectives. Inspired by the Business Model Canvas of Alexander Osterwalder[15], a design canvas is created to ideate and conceptualize intelligence amplification applications. In addition, a supporting design workshop is developed in collaboration with Vereniging Logistiek Management. Together with Logistiek.nl a micro-lecture and tutorial was created for the online event “De Week van Logistiek” as shown in **Figure 9**.



Aletta Martens Moderator
Graag tot ziens bij de Tutorial van Sebastian Piest om 12.00uur!

OrOnDiBa Consultancy
Zeer boeiende film over AI en prettig gepresenteerd.

Manon Baartmans
mooie use case op Moerdijk van Kien ;-)

Figure 9: Online micro-lecture and tutorial for “De Week van Logistiek.nl”.

Inspired by Prof. Dr. Ir. H.H. van den Kroonenberg, former professor, rector magnificus and ideator of the "entrepreneurial university", a valorisation plan is developed. Next to incorporating research results and cases in educational programs, alternative ways were explored to share the results and increase the impact. Following up on the series of research posters about research projects at the University of Twente that were created for Create Tomorrow[16], a collaboration with cartoonist LUVANE resulted in a series of illustrated posters for the TKI DINALOG project. The illustrated posters are included in **Appendix C**. Based on various contacts and the AI roundtable organized by TKI DINALOG, a follow-up project is initiated and granted. In the TKI DINALOG project “*Industry 4.0 driven Supply Chain Coordination for Small and Medium-sized project Enterprises (ICCOS),*” research

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[15] https://www.strategyzer.com/canvas/business-model-canvas
[16] https://www.utwente.nl/en/business/cases-inspiration/research_posters/

is conducted together with 8 consortium partners regarding the use of the IDS reference architecture for logistics applications and adoption of IDS by SMEs (TKI DINALOG, 2022c). Building upon the results, ICCOS aims to further scale up the deployment and use of artificial intelligence and investigate the impact of I4.0 technology adoption regarding the logistics practice and modern education. The University of Twente is the main applicant and project leader of the ICCOS project. Participating consortium partners, shown in **Figure 10**, are: ABC Flows, Bullit Digital, Deltago, Districon, Emons Group, King Nederland, LOGAPS and Veenman. The ICCOS project is a multidisciplinary, 2 year research project that aims to design, develop, and prototype a multi-agent system for selected use cases in the logistics sector. Both projects form the basis for this PDEng thesis.

Figure 10: Consortium meeting for the ICCOS project.

Current research takes place in the NWO Accelerator project Reinforcement LeArning Platform for Logistics SMEs (ReAL) (TKI DINALOG, 2022d) and IDS connector store and interoperability simulator for SMEs (CLiCKS) (NWO, 2022).

2.6 Knowledge utilization and impact plan

The University of Twente coordinated the knowledge utilisation activities together with consortium partners, regional networks, and branch organizations. The consortium made the results available to transport and logistics companies via new or improved tools and will promote usage in a later stage via SUTC, representing members of Evofenedex and TLN. To further improve the outreach to the industry, the consortium partners actively involved their supply chain partners and their customer base. The consortium took an active role in sharing research outcomes and organize presentations for the logistics industry at well-attended events (e.g., ICT & Logistiek, Transport & Logistics) and events organized at TLN, Evofenedex, TKI DINALOG and others. The results are also used to develop new and improved educational materials (e.g., lectures, tutorials, project assignments) and incorporate these results in the educational programmes at the University of Twente. The consortium partners were also involved in the knowledge transfer by giving guest lectures, as shown in **Figure 11**, and incorporating projects as lecture cases in educational programs.

Figure 11: Guest lectures by consortium partners.

In addition, workshops were organized for ensuring the dissemination and diffusion of the results throughout the logistics community. A hybrid learning community is developed to accelerate the adoption of data-driven logistics and aid SMEs to implement the platform using their own data. Deltago together with the University of Twente developed teaching materials and demos for the training of logistic professionals, initiate pilot projects with interested SMEs, and develop a supporting ecosystem. Together with Breda University of Applied Sciences the first workshops are organized. Together with Port of Twente, which has approximatively 80 members, the workshops will be offered to scale up. The above is visualized in the societal impact plan shown in **Figure 12**.

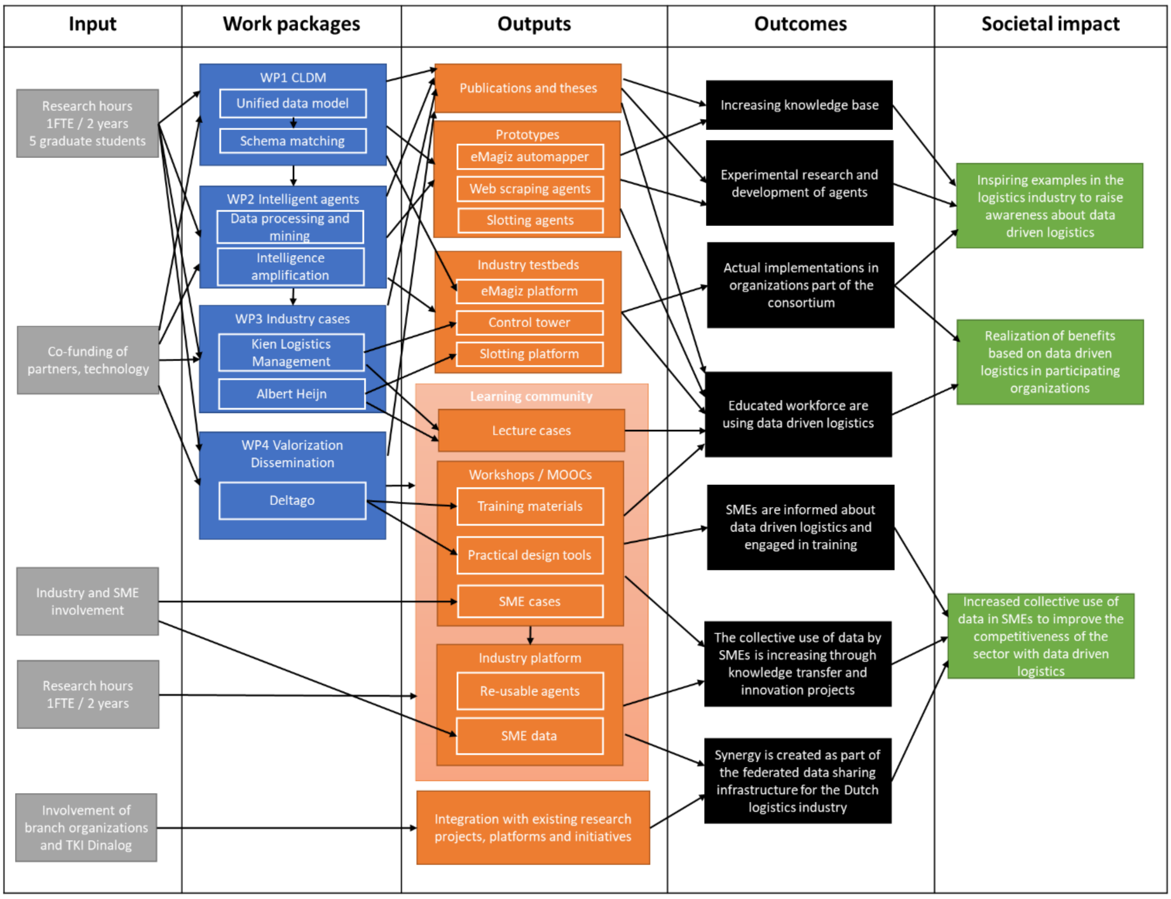

Figure 12: Societal impact plan (created based on NWO template).

The research is financially supported by the Dutch Ministry of Economical Affairs and co-financed via TKI DINALOG and NWO. The inputs for the impact plan are research hours over the course of the project of involved researchers and graduate students, co-funding of consortium partners in time and technology. Research is conducted as part of the described WPs and related to specific outputs, including academic publications, prototypes, and software artefacts. Extending the testbeds for experimental development, the learning community comprises a combination of lecture cases, workshops for logistics professionals, and use of the industry platform. This way, the industry platform is used to scale up the results within the industry and increase the impact of the project by involving more SMEs from the Dutch logistics industry. The involvement of branch organizations and TKI DINALOG is foreseen at a later stage to integrate related research projects, platforms, and initiatives.

2.7 Summary and conclusion

The research project, related to this PDEng thesis, resulted in multiple deliverables and follow-up projects. The initial 2-year project resulted in publications, prototypes, industry testbeds, implementations in 3 organizations, training materials, design tools, and lecture cases. These results are documented in the final project report and broadly disseminated in both the scientific and industrial community based on the impact plan. Building on the initial project, the current research resulted in an industry platform and learning community to 1) raise awareness about data-driven logistics with inspiring cases, 2) increase data use in SMEs, and 3) scale up the results via a learning community to increase the competitiveness of the Dutch logistics industry. In follow-up projects, additional cases are developed and the industry platform is implemented in more SMEs.

PROGRAMME OF REQUIREMENTS

3 Programme of requirements

This chapter presents the programme of requirements. **Section 3.1** describes the industrial context of the research and the main stakeholders. **Section 3.2** presents the industry platform requirements. **Section 3.3** presents future scenarios for societal embedding of the design. **Section 3.4** summarizes and concludes the chapter. This chapter contains parts of published articles and individual course work from the PDEng program.[17]

3.1 Stakeholders

This section describes the industrial context of the research and the main stakeholders.

Subsection 3.1.1 establishes the research context in the logistics industry	**Step 2 of DSRM**
Subsection 3.1.2 identifies the main stakeholders of the industry platform	Solution objectives

3.1.1 Logistics industry

The logistics sector can be seen as a network where multiple organizations come together to plan, organize, coordinate, and execute processes related to the physical transportation of goods and logistics services. Naturally, a logistic process involves multiple parties (e.g., shippers, LSPs, transport operators, or carriers), different entities or departments within an organization (e.g., planning, sales, finance), and is spread across different geographical regions (e.g., domestic, international). As a result of globalization, logistic processes are exceedingly complex and dynamic, and logistic data usually comes from heterogeneous data sources in various (un)structured formats (Intayoad and Becker, 2018).

The stakeholders related to the envisioned industry platform mostly belong to the Dutch logistics industry, including shippers, transport operators, logistics services providers, (open) data providers, and governmental organizations. Based on the high-level concept, depicted in **Figure 13**, the most important stakeholders, their systems, and interfaces are identified. This overview illustrates the central role that LSPs have and emphasizes the importance of interoperability to collaborate with business partners and connect their systems. Static order data are received from the ERP system and/or WMS of the shipper or forwarder. The LSP has a TMS and/or FMS to connect on-board computers in the vehicle (of the third-party carrier). This enables real-time track and trace of shipments and related goods and assets. Additionally, all parties can obtain open data to enrich internal data

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[17] **Subsection 3.1.1** is based on the position paper (Piest et. al., 2021) and **Subsection 3.1.2** is related to the research paper (Piest et. al., 2021). **Section 3.2** is based on the research paper (Piest et. al., 2021) and extended with assumptions and the design rationale. **Section 3.3 and 3.5** are based on individual course work. The safety, risk, and ethical assessment are included in **Appendix E and F** to create a multidisciplinary view.

and exchange data via logistics information platforms and EDI brokers. Parties also use the data for reporting or BI purposes.

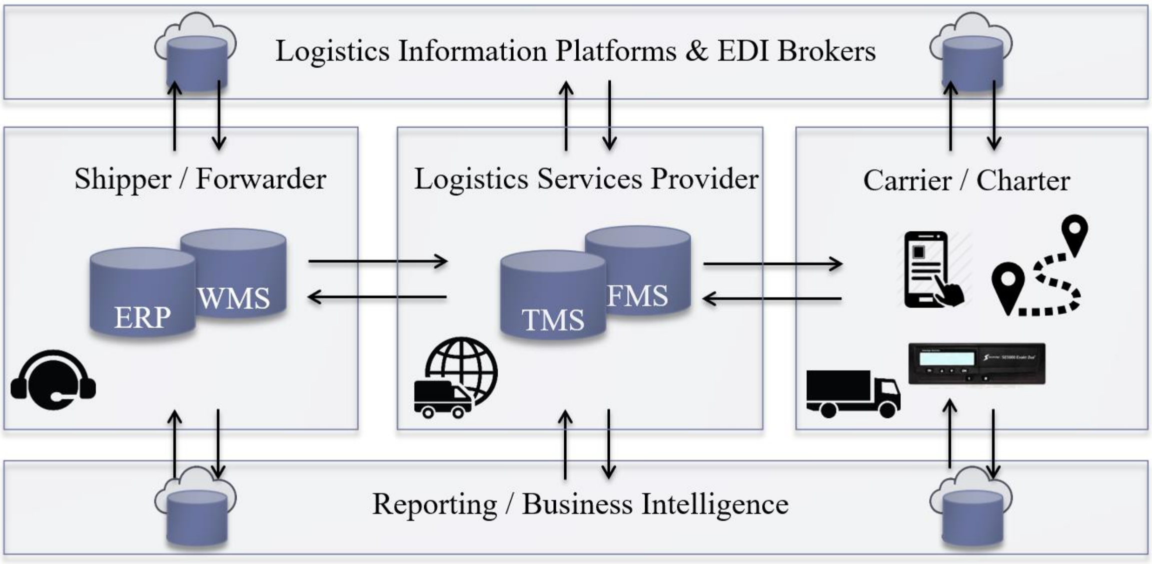

Figure 13: Common logistics interoperability scenario with different parties and systems (image: Piest, 2021).

As illustrated by the industry surveys in **Chapter 1**, shipment data are generally administered in multiple information systems (e.g., ERP, WMS, TMS, and FMS) (InfoResult, 2018; Evofenedex, TLN and Beurtvaartadres, 2019, InfoResult, 2021). Each business transactions creates a trail of events, which is used to track and trace the status of shipments and whereabouts of goods during the physical handling processes. Data are exchanged via different channels (e.g., email and EDI) and supported by industry standards and interoperability models (Evofenedex, TLN and Beurtvaartadres, 2019). The OTM is such a data exchange standard that is increasingly being adopted by the Dutch logistics industry and also positioned as one of the main building blocks for the federated data sharing infrastructure (Bastiaansen et al., 2020). In the industry, the OTM data model is also used for reporting and BI, as illustrated in **Figure 13**, however, to our best knowledge, not for advanced data analytics, process mining, ML and AI. In the position paper (Piest, 2021), the idea of using the OTM for process mining is positioned based on an informal conceptual mapping study. Some initial support is obtained via a relatively simple experiment. The ideas put forward in this position paper and completed future work is incorporated in this PDEng thesis.

3.1.2 Industry platform

Based on the identified stakeholders in **Subsection 3.1.1**, the onion diagram of Alexander and Robertson (2014) is used to assign the stakeholders to different layers and roles related to the industry platform. **Figure 14** visualizes the onion model, marks the scope of the research project and development team, and visualizes the relationships between the stakeholders. **Table 5** presents an overview of the layers of the onion model, the identified stakeholders, their roles, and the specific organizations that fulfilled these roles during the design, development, and implementation of the industry platform. Eventually, the industry platform aims to complement the reporting and BI systems shown in **Figure 13**. Societal embedding of the design is discussed in **Section 3.4**.

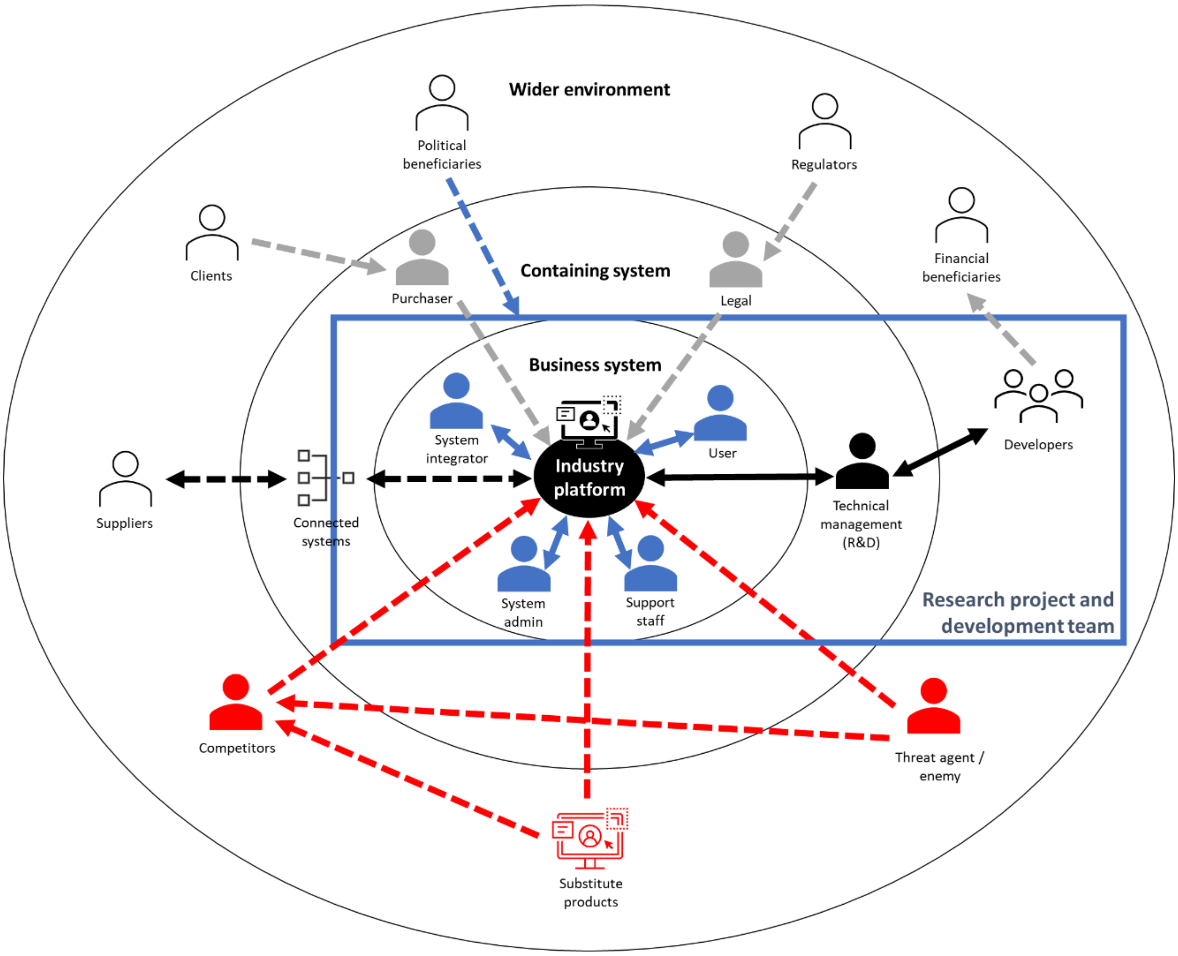

Figure 14: Visual overview of stakeholders and relations (adapted from Alexander and Robertson, 2014).

The industry platform is positioned in the centre of the onion model. The scope of the research project is marked by the blue rectangle. The development of the industry platform is the direct responsibility of the technical management (R&D) team, selected developers, and actors within the business system. The business system is formed by the user, system administrator, support staff and system integrator. Although connected systems are considered in the design of the industry platform, by means of operationalization of APIs based on the OTM, the research project does not primarily focus on connecting operational systems and exchanging data with suppliers of logistics information systems. The same goes for the purchasers, clients, and financial beneficiaries of the system. The influence of legal is acknowledged, as well as the role of regulators, but these roles are not explored in detail in this research project. Furthermore, the most important negative stakeholders are identified, including competitors, substitute products and threat agents, but their role is not elaborated as part of this research project. The solid arrows represent direct relationships between actors and the industry platform. The dotted arrows represent indirect relationships between arrows and the industry platform. The dotted lines between suppliers, connected systems and the industry platform represent data exchange. The dotted lines between clients, purchasers, and the industry platform represent exchange of value. Although the economical relationships are considered important, the main focus is aimed at technical and societal aspects.

Layer	Stakeholder	Role	Represented by
Business system	User (normal operator)	Transport planner, business analyst	Emons
	System admin (operational support)	(External) IT support employee	Emons
	Support staff (maintenance operator)	(External) IT specialist	Emons
	System integrator	(External) integration specialist	Bullit Digital
Containing system	Purchaser	CEO, management, IT	Emons
	Connected system(s)	ERP, WMS, TMS, FMS, board computers, IoT devices	Via SUTC, independent IT expert
	Technical management (R&D)	Product manager, system architect	Research team, Bullit Digital
	Legal	Bookkeeper, finance	Emons
Wider environment	Clients	Shipper, transport operator, LSP	Via Emons in a later stage
	Suppliers	Data providers	-
	Developers	Illustrator, User Interface / User Experience (UI/UX) designer, software developer, data scientist	Sjusjun, Niké Creatief, Bullit Digital
	Financial beneficiaries	Infrastructure vendor, reseller	Microsoft
	Political beneficiaries	Standards bodies, branch organization	SUTC, Evofenedex
	Regulators	Customs, tax agency	-
	Competitors	Logistics platforms, EDI brokers	Independent logistics IT expert
	Substitute products	Data analytics tools, custom coding	-
	Threat agent / enemy	Cyber criminals	-

Table 5: Stakeholders and their roles.

3.2 Industry platform requirements

This section presents the industry platform requirements gathering and classification.

Subsection 3.2.1 describes the process of requirements gathering	**Step 2 of DSRM**
Subsection 3.2.2 lists the assumptions that are made regarding the context	Solution objectives
Subsection 3.2.3 emphasizes the design rationale of the industry platform	
Subsection 3.2.4 contains the programme of requirements	

3.2.1 Requirements gathering

The requirements for the industry platform are gathered and elicited based on a round table with the Council for Logistics Knowledge of Evofenedex (**Appendix D**), workshops with the organizations mentioned in **Table 5**, literature reviews as part of earlier and related work (Piest, 2019 and 2021), and industry surveys conducted in the Dutch logistics industry by Evofenedex, TLN and Beurtvaartadres (2019) and InfoResult (2018 and 2021). The round table was organized at the beginning of the research project (27-09-2018) and provided insight regarding the relevance of the topic and need for inspiring examples. Furthermore, the insights emphasize the need for guidelines regarding questions such as “Where and how to get started?” and modern forms of education to reach and engage SMEs to get started with data-driven logistics. Throughout the initial 2-year research project, case-based research was conducted to examine data use and technology adoption in a small, medium-sized, and large enterprise. During the PDEng courses regarding systems design and engineering, an initial list of requirements was gathered for the industry platform and assessed from a safety and risk perspective (**Appendix E**) and using Ethics Guidelines for Trustworthy AI of the High-Level Expert Group on AI (European Union, 2019) (**Appendix F**). In the ICCOS project, consortium meetings were organized to verify the requirements. Together with Bullit Digital, the programme of requirements is assessed from a technological perspective and connected to involved consortium partners and external experts. The results are presented in **Subsection 3.2.4**.

3.2.2 Assumptions

Based on the industry surveys, literature review, and meetings with consortium partners, the following assumptions are formulated:

- SMEs have an operational focus and pressure on results, investments in technology must have a quick return on investment and contribute to improving operational performance;
- SMEs have limited time, resources, IT knowledge and skills, the implementation and use of the industry platform should require limited training, time, and efforts, preferably by people without a technical background and require limited/no external assistance;
- SMEs do not know nor apply enterprise architecture and look for practical solutions that can be implemented and integrated in daily operations with limited efforts and change;

- Most of the SMEs do not have specialized:
    - Middleware software or integration platforms;
    - Application development platforms;
    - Data science tools.
- Excel is the main data analysis tool for SMEs, because it is:
    - Part of the Office license and available for use;
    - Relatively easy to use and does not require much IT skills;
    - Broadly used in the sector for reporting and data sharing with partners.
- Decisions about technology adoption in SMEs are made by CEOs and owners, therefore the industry platform must be understandable for higher management;
- Implementation of new technology in SMEs is done by line managers and logistics professionals with a non-technical background, ideally without involvement of IT and external assistance as part of the learning community;
- Based on the industry surveys, the main data use goals are:
    - Lower costs and increase efficiency;
    - Provide better services for customers;
    - Reporting results and learn from the past;
    - Improve resource utilization and operational performance;
    - Improve visibility and support decision-making;
    - Detect exceptions and predict/forecast disruptions;
    - Develop new products and services.

3.2.3 Design rationale

Based on the industry surveys and assumptions, the current information systems are considered not suitable for advanced analytics and AI applications. Excel offers rich spreadsheet functionality and can fulfil needs regarding reporting, data analytics, and basic forms of BI. Additionally, Excel can offer data mining capabilities, but these advanced applications and implementations require additional server set-up and technical knowledge and skills. Excel often runs on local laptops or computers and is error prone. Furthermore, Excel has limited processing capabilities and performance issues can be expected with large datasets. Existing reporting, BI, and data science tools can provide additional functionality, but require IT knowledge and skills, IT investments, software license subscriptions, support contracts, and external training and consultancy. Hiring a specialized data analyst or BI professional introduces a financial barrier (~€80.000,- to €100.000,-) and requires investments in IT tools and software subscriptions. Next to these Operating Expenditures (OPEX), projects require internal resources, external assistance, and other related Capital Expenditures (CAPEX). Thus, there is not just a financial entry barrier to get started developing data-driven logistics applications, but also a fixed and variable aspect to consider. Several studies of Forrester regarding the Total Economic Impact (TEI)[18] illustrate the significant investments and long-term commitments that are required as well as the uncertainties and risks involved to realize benefits. Typically, SMEs have limited financial and human resources available to initiate large scale IT portfolios. Instead of designing and developing dedicated solutions for individual organizations, a collective approach and industry platform, as positioned in **Subsection 1.2.2**, can offer a feasible and cost-effective solution for SMEs. Such an approach is implemented and evaluated for SMEs using a web-based decision support system based on agent mining (Ponis and Christou, 2013). This provides some support of the technological feasibility. The design rationale behind the envisioned industry platform and supporting learning community, that is tested and assessed upon completion of this research project, is that a collective approach can lower the financial entry barriers in terms of CAPEX for SMEs to adopt data-driven logistics applications and over a longer period of time lower the CAPEX and OPEX based on network effects (e.g., by re-using algorithms and sharing investments). However, prior to societal embedding, this research project aims to test the technological feasibility of such a collective approach by realizing the envisioned industry platform for data-driven logistics and establish a supporting learning community for SMEs in the Dutch logistics industry.

3.2.4 Classification of industry platform requirements

The scope of the industry platform is limited to the business system and parts of the containing system as marked in **Figure 14**. The wider environment perspective is partially explored so it can be assessed in a later stage with other involved SMEs as part of the learning community. **Table 6** presents an overview of the industry platform stakeholders, their goals, requirements, and constraints. Each requirement is briefly described, including candidate Technical Performance Measures (TPMs) and Key Performance Indicators (KPIs), and possible constraints. The list of requirements is used as a long list for the design and development of the industry platform in **Chapter 6**.

Stakeholders	Goals	ID	Requirements and measures	Constraints
User	Support operational processes and decision-making	U1	Enhance problem solving capabilities: - TPM: time to make decision - KPI: accuracy, error margin	Time
		U2	(Partially) automate tasks related to decision-making: - TPM: manual / automated decisions - KPI: number of tasks executed manual / automated	Efforts

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[18] https://www.forrester.com/policies/tei/

		U3	Utility of the system in daily operation: - TPM: # of use cases supported - KPI: user satisfaction score	Efforts
		U4	Ease of use of the system: - TPM: time to on-board new user - KPI: training cost and time	Training efforts, IT knowledge
		U5	Time efficient to use: - TPM: user activity in time - KPI: idle / active time	Time
		U6	Non-invasive in use: - TPM: use of the as-is functionality - KPI: software customization cost	Change required
System admin	Manage users and system configuration	A1	Administer users: - TPM: time to add user - KPI: time spent on administration	Time
		A2	Configuration of master data: - TPM: # inputs in configuration screens - KPI: set-up time	Parameters
		A3	Ease to understand the system functionality: - TPM: time to on-board - KPI: training cost and time	Training efforts
Support staff	Maintain the system and provide end-user support	S1	Log transactions and events: - TPM: log database actions for at least 30 days - KPI: completeness of log	Resources
		S2	Monitor the performance and health of the system and integrations: - TPM: log web service transactions - KPI: service availability / uptime	Supervision efforts
		S3	Ease to understand the full system: - TPM: time to become key user - KPI: training cost and time	Training efforts
		S4	Solve technical issues independently: - TPM: 3rd party service requests - KPI: external consultancy costs	External assistance required
System integrator	Retrieve data from internal systems and connect to	I1	Connect systems and external parties: - TPM: web service operations - KPI: # web service users	Time, investment

	external parties and data sources	I2	Syntactic and semantic integration with different information systems: - TPM: formats and schema mappings - KPI: # systems connected	Efforts
		I3	Technical connection with different protocols and internal infrastructures: - TPM: connectors and adapters - KPI: # endpoints / connections	Efforts, external assistance
Purchasers	Cost-effective solution	P1	Positive and short return on investment: - TPM: system CAPEX / OPEX - KPI: cost reductions / productivity gains / benefit realization	Investments, resources
Connected system(s)	Interoperability with external systems	C1	Support interorganizational processes: - TPM: shipment lifecycle support - KPI: supported choreographies	Change required
		C2	Harmonize (heterogenous) data formats: - TPM: mapping of data to OTM - KPI: custom code / scripts	Time, efforts
		C3	Documentation for developers: - TPM: documented versions - KPI: developer satisfaction / support requests	External support required
Technical management (R&D)	Develop a platform for a broad group of SME users that adheres to the needs and specifications in the industry	T1	Generalize use cases in logistics: - TPM: use cases supported - KPI: re-usable templates	User needs
		T2	Standardize algorithms: - TPM: template code / scripts - KPI: re-usable algorithms	Efforts, IT knowledge
		T3	Compliant to industry standards: - TPM: comply to OTM version 5 - KPI: supported versions	Specification
		T4	Ensure data sovereignty: - TPM: access-authorization controls - KPI: usage policies configured	User needs
		T5	Scalability: - TPM: jobs for computation - KPI: RAM, Disk, Network utilization	Resources

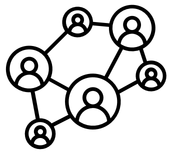
		T6	Cybersecurity: - TPM: audit procedure - KPI: security breaches	Framework used
Legal	Adherence of the organization with laws, rules, and regulations	L1	Compliant to laws and regulations: - TPM: based on software terms - KPI: claims	Applicable law
		L2	Compliance to GDPR: - TPM: GDPR procedure - KPI: privacy breaches	Efforts
		L3	Audit log and authorizations: - TPM: log user actions for 30 days - KPI: completeness of log	Supervision efforts

Table 6: Stakeholder goals, requirements, and constraints.

As mentioned earlier, the gathered and elicited industry platform requirements are used as input for the platform design and development, which is described in **Chapter 6** in more detail. The main focus is on the R&D goal and requirements (T1-T6) and initial validation of the business system.

3.3 Societal embedding of the design

In the current context, the designed and developed industry platform is part of the temporal context of the 2-year research project. This project involves experimental development and normally will not be deployed in actual operational environments. However, to realize the envisioned impact as described in **Section 2.6**, actual implementation of the industry platform and supporting learning community is an important prerequisite. Based on course work in the PDEng program, societal embedding of the design is used to explore possible future states, for example a commercial spin-off. Future scenarios are developed to explore the actual implementation of the industry platform to extend the current temporal research context. Based on the stakeholder analysis, four scenarios, with different levels of stakeholder involvement, and transition pathways are defined regarding societal embedding of design over a time span of 5-15 years. The first and second scenario explore the future in the case of a spin-off. The third scenario explores the future in case of a follow-up research project. The fourth scenario explores the future in the case of discontinuation of the project. **Table 7** contains the scenarios, stakeholder involvement, transition pathways, and impact.

Nr.	Scenario	Description	Transition pathway	Impact over time
1.	 **Non-profit co-operation**	The research team and consortium partners establish a cooperation for further development	Go to market based on break-through innovation and disruption. Utilize the stakeholder support	The cooperation develops a large variety of applications, active developer community and ecosystem. Given the scientific

		of the industry platform. TKI DINALOG, Topsector Logistiek and technology providers support the team to make the platform widely available for SMEs in the sector and realize the envisioned broader societal impact.	to de-align the current system regime and form a cooperation for collective product development. Use the market attention and learning community for scaling up, development of novelties, and create focus groups for the accumulation of niches.	base, case studies at consortium partners, developed products, and the learning community together facilitates large scale implementation of the industry platform. Additional research projects are acquired to further develop the platform and continue research. The scientific output is well cited and follow-up research increases the scientific footprint of the research team.
2.	**Spin-off as a commercial start-up**	Contrasting to the first scenario, the team launches a commercial spin-off and faces difficulties commercializing the developed product. Much time and money are lost on re-engineering the product. The team does not get support of TKI DINALOG and the Topsector Logistiek to commercialize the product.	Go to market based on break-through innovation. Focus on learning processes to align and function within the current system regime. Search for historical studies on transitions and niche dynamics to position and align product development to the existing system regime.	Significant R&D investments are needed to fulfil the needs of prospects. The focus on commercialization and product development does not leave any time to do research. The scientific output is initially well cited, but over time the growth in citations stagnates. Researchers eventually lose interest and start working on other projects.

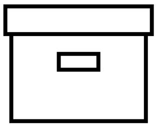
3.	 **Project continuation in follow-up research**	The research team secures additional funding to continue the project with the consortium partners, TKI DINALOG and the Topsector Logistiek.	Utilize the stakeholders support to align with the current system regime and obtain funding to continue research and develop novelties. Expand the learning community and attract technology partners to develop add-ons for the industry platform.	The developed product is incrementally improved and used in educational programs. However it provides a rich source for experiments and scientific research, the technology providers eventually lose interest in developing the product without additional sales opportunities. The scientific output is well cited and follow-up research contributes to increase the scientific footprint of the team.
4.	 **Project discontinuation**	Contrasting the first, second, and third scenario, the research project is discontinued.	No alignment with the current system regime elements. The industry platform and learning community are dismantled. The project is archived according to the data management plan.	The research team is looking for new projects. The consortium partners refer to the project in the first period after the project was concluded, but it will be replaced by follow-up projects and business as usual. The scientific output is being cited in the first period after the project, but then loses the attention of the scientific community.

Table 7: Scenarios and stakeholder strategies for societal embedding of the design.

Societal embedding of the design requires a long-term commitment and involvement of different stakeholders. Stakeholder salience strategies can be applied to extend the impact plan, described in **Section 2.6**, and support the further exploration and assessment of the feasibility of the scenarios and potential alternatives. Dominant stakeholders can be invited to be part of a supervision board and involved in the roadmap development. Dormant stakeholders can be informed periodically and their feedback can help verify ideas for novelties. Developments in the area of legislation must be monitoring frequently and can be analysed using risk management approaches. These strategies can be incorporated in the business or project plan and supporting communication plan.

3.4 Summary and conclusion

This chapter documents the programme of requirements for the industry platform. The stakeholders for such an industry are identified, and requirements are gathered and elicited. Realizing the industry platform is a significant engineering effort and requires involvement of many stakeholders. The program of requirements entails 28 requirements. The safety and risk assessment illustrate the diverse relations between humans interacting with the system, and the relation to the wider environment. The assessed 15 aspects emphasize that actual implementation requires incorporation of many other aspects to cover the full lifecycle. The ethical assessment adds 7 important requirements to ensure trustworthy AI applications. Given the limited time span of the 2-year PDEng program, the focus is on realizing the industry platform and related requirements. However the focus of the PDEng is on technological design and development of the industry platform for industrial research, the broader societal impact is assessed. Societal embedding of the design is applied to explore future scenarios.

LITERATURE REVIEW

4 Literature review

This section provides a review of relevant academic literature, earlier and related work. **Section 4.1** describes the literature review and reporting process. **Section 4.2** summarizes research in the area of enterprise architecture and technology adoption in SMEs. **Section 4.3** provides insights regarding data analytics and -mining in logistics. **Section 4.4** highlights process mining applications in logistics. **Section 4.5** addresses interoperability challenges. **Section 4.6** discusses AI applications and focuses on reinforcement learning in logistics. **Section 4.7** discusses relevant approaches for performance measurement and monitoring. **Section 4.8** summarizes earlier and related work. **Section 4.9** summarizes and concludes the chapter. This chapter is based on published articles.[19]

4.1 Literature research and reporting process

Following the research design in **Section 1.3** and the iterative approach for research and reporting of Verschuren and Doorewaard (2015), relevant literature is collected using Scopus[20] and IEEE Xplore[21] based on the eight-step guide of Okoli and Schabram (2010). Step 1 identifies the purpose of the review. Step 2 describes the protocol and required training for reviewers. Step 3 contains the search for literature. Step 4 involves practical screening for inclusion of articles. Step 5 involves quality appraisal and exclusion of articles. Step 6 is concerned with data extraction. Step 7 is aimed at synthesis of the results. Step 8 is concerned with writing the review. The application of the eight-step guide is included in **Appendix G**. The results and findings are analysed throughout the course of the ALM and ICCOS research projects, as introduced in **Chapter 2**, and resulted in multiple reports and publications. **Figure 15** visualizes which literature reviews are conducted and how related publications are incorporated in this PDEng thesis.

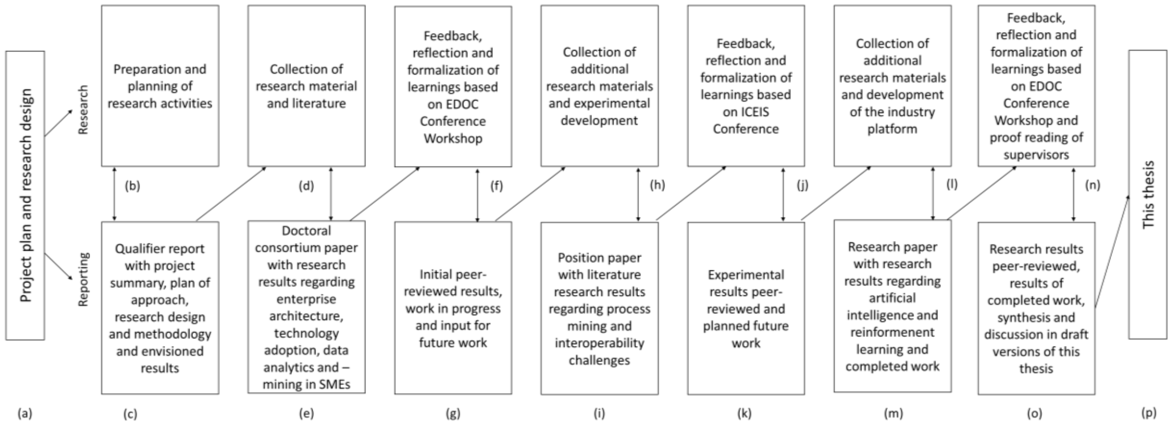


Figure 15: Visual overview of the literature reviews (adapted based on Verschuren and Doorewaard, 2015).

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[19] **Section 4.2 and 4.3** contain parts of the doctoral consortium paper (Piest, 2019). **Section 4.4 and 4.5** are based on the position paper (Piest et. al., 2021). **Section 4.6** is related to the research paper (Piest et. al., 2021). **Section 4.7** is added to extend earlier work.

[20] https://www.scopus.com/

[21] https://ieeexplore.ieee.org/

Based on the research design and project plan (a), subsequently described in **Section 1.3** and **Chapter 2**, the research is prepared and planned (b). During the qualifier meeting, the research planning is assessed (c). Next, the collection of research material and literature started (d). The qualifier report and preliminary literature review results are incorporated in the first publication (e). The results are presented in **Section 4.2 and 4.3**. Based on feedback, reflection, and formalization of learnings from the EDOC Conference Workshop (f), the initial peer-reviewed research and work in progress is completed and input is incorporated for future work (g). Additional research materials are collected, and the experimental development is completed (h). The position paper presents the technology approach (TRL 2) and reports the results and findings of experimental use of the OTM for process mining (TRL 3) and interoperability challenges (i). The results are presented in **Section 4.4 and 4.5**. Based on feedback, reflection, and formalization of learnings from the ICEIS Conference (j), the experimental peer-reviewed research is continued and planned future work is defined (k). Additional research materials are collected, and the industry platform is developed (l). The research paper presents literature review results regarding AI and RL and reports the results and findings of completed work regarding the industry platform (TRL 8) and case-based research at Emons (TRL 9) (m). The results are presented in **Section 4.6**. Based on feedback, reflection, and formalization of learnings from the EDOC Conference Workshop and proof reading of supervisors (f), the research results are peer-reviewed and documented in draft versions of this PDEng thesis (o). Additional literature research is conducted and documented in **Section 4.7** and related and earlier work is summarized in **Section 4.8**. to extend the results and findings of individual works. The literature review is repeated for this PDEng thesis to update and extend earlier work. Next, **Subsections 4.2 – 4.8** summarize and synthesize the results of the literature reviews and earlier work in relation to the research design.

4.2 Enterprise architecture and technology adoption

Enterprise architecture and technology adoption in SMEs are widely studied in different domains. Existing methods and techniques are evaluated by several authors, e.g., Zachman's framework, The Open Group Architecture Framework, and ArchiMate (Bernaert et. al., 2014; Gerber, le Roux and van der Merwe, 2020). Interesting, related work focusing on enterprise architecture and technology adoption in SMEs is done by Bernaert et. al. (2014). Based on a survey among SMEs in Flanders, the authors suggest that SMEs do not know nor apply enterprise architecture and argues that SMEs require a different, more simplified, enterprise architecture compared to large organizations (Bernaert et. al., 2014). The authors propose a model consisting of four dimensions of the business architecture, incorporating: a strategic dimension (why), active actor dimension (who), operation dimension (how) and object dimension (what). The model is accompanied by supporting criteria, currently referred to as CHOOSE, and software tool support (Dumeez, Bernaert and Poels, 2013;

Bernaert, Maes and Poels, 2013). CHOOSE is an acronym: Control, Holistic Overview, Objectives, Suitable for target audiences Enterprise (Bernaert, Poels and Snoeck, 2016). The approach is mapped to ArchiMate and is considered relevant for this research project and incorporated in the program of requirements. Boone et. al. (2014) evaluated several visualizations of CHOOSE. An alternative, light-weight approach is developed by Tschoppe and Drews (2021).

Regarding technology adoption, Ghobakhloo et. al. (2012) reviewed literature regarding IT adoption by SMEs and propose a conceptual model for IT adoption that incorporates influencing external and internal factors in SMEs. Based on their review, internal factors are identified and grouped by: top management (CEO), resources, end-users (staff) and organizational behaviour and characteristics. External factors are identified and grouped by: IT products offered on the market, external and competitive pressure, government and external IT consultants or vendors. The authors propose a conceptual model for effective IT adoption within SMEs that is divided in three stages: 1) initial adoption, 2) implementation, and 3) post adoption. Abed (2018) reviewed empirical research examining SME adoption and identified 35 journals with 68 studies in the period 1995-2017. The author mapped factors to the technology, organization, and environment framework to identify dominant factors. A similar study is conducted by Nguyen (2009). The author developed an integrated framework with multiple dimensions. Bernaert et. al. (2014) describes six requirements that influence IT adoption by SMEs that can be used as a starting point for enterprise architecture in SMEs based on design science. The six requirements for the successful adoption and use of IT in SMEs are: 1) approaches should enable SMEs to work strategically in a time efficient manner, 2) the intended user should be able to work with the IT with limited IT skills, 3) little assistance of external experts is required for the approach, 4) the approach should be able to make process descriptions in the whole company, 5) involvement of the CEO, and 6) the expected benefits or revenue should exceed anticipated costs and risks.

4.3 Data analytics and -mining

Data analytics and -mining is an established research field that contain numerous methods and techniques. Several reviews are conducted, including reviews regarding big data analytics in logistics and supply chain management (Wang et. al., 2016; Yudhistyra et. al., 2020), supply chain decision-making based on IoT and big data analytics (Koot, Mes and Iacob, 2021), and data mining and machine learning (Tsolaki, 2022). Wang et. al. (2016) classifies a variety of big data analytics techniques, including statistical analysis, simulation, and optimization, on strategic and operational level. The authors analyse descriptive, predictive, and prescriptive analytics and propose a maturity framework, distinguishing specific functional, process-based, collaborative, agile, and sustainability analytic approaches, and a holistic business analytics approach. Yudhistyra et. al. (2020) reviewed literature for big data analytics techniques and related these to the evolution of logistics to supply chain management. More recent, a systematic literature review is conducted by Koot, Mes, and Iacob (2021) regarding supply chain decision-making bases on IoT and big data analysis. The authors relate IoT networks to data analytics techniques and decision-making. The TRL regarding intra- and interorganizational activities in supply chains are assessed and visualized. More specifically, 79 studies are mapped based on perception layer, stimuli, network layer, data management, pattern recognition and types of algorithms, analytics, decisions and related hierarchy, supply chain activity, TRL, and KPIs. Tsolaki et. al. (2022) reviewed data mining and machine learning applications in freight transportation and logistics, including: arrival time prediction, demand forecasting, industrial processes optimization, traffic flow and location prediction for intermodal transportation, the Vehicle Routing Problem (VRP) and anomaly detection on transportation data. These studies indicate a rich spectrum of use cases that can be considered when developing data-driven logistics applications.

The usage of data analytics and data mining methods in SMEs is discussed by several researchers. The study of Mohd Selamat et. al. (2018) shows that the main methods that are applied in SMEs in transportation are Knowledge Discovery in Data (KDD), Sample, Explore, Modify, Model and Assess (SEMMA), and the CRoss-Industry Standard Process for Data Mining (CRISP-DM). The authors point out that the main limitations of KDD, SEMMA, and CRISP-DM for SMEs are the required technical knowledge and the extensiveness of the method. This connects well to enterprise architecture research in SMEs and CHOOSE. Furthermore, the study indicates that SMEs typically lack the resources and knowledge for data mining and have concerns about data management. Moreover, 10 barriers for SMEs are identified that influence the adoption of big data analytics. The authors argue that data mining is critical for SMEs to improve decision-making and performance. Similarly, Coleman et. al. (2016) listed 14, mostly similar, challenges SMEs face concerning big data analytics and present a maturity model and growth path for SMEs. The technological requirements and barriers for SMEs are addressed by evaluating open-source systems for SMEs (Chen et. al., 2007; Almeida and Bernardino, 2016; Kalan and Ünalir, 2016). Data analytics and -mining are also compared with regression methods by Chertchom (2018). The knowledge and organizational issues of SMEs are discussed by Izquierdo and Larreina (2005) and a collective approach is proposed for technology watch and competitive intelligence through intermediate R&D centres by Ponis and Christou (2013). This competitive intelligence approach has been implemented in a web-based decision support system for SMEs based on agent mining. The idea for a collective approach is adopted in this research project.

4.4 Process mining

Process mining focuses on extracting knowledge from data generated and stored in the databases of information systems in the form of event logs (Van der Aalst et al., 2012). Logistic processes generate large amounts of event data. Event data are expected to be a rich source for behaviour analysis as it comprises data concerning the dynamic behaviour of people, objects, and systems at a detailed level. Process mining techniques can be helpful to produce insights based on logistic event data. There are several studies available on process mining in the logistics domain. A systematic mapping study (dos Santos Garcia et al., 2019) illustrates that less than 5% of their paper sample is about the logistics domain. This mapping study identified 27 studies with a focus on logistic processes, including transportation, storage of goods, and inventory management. Most of the studies focus on process discovery in the logistical context. Specific studies examine process mining in regard to network analysis, resource configuration, prediction of event times, and remodelling of business processes. Additional studies examined logistic processes through process mining, mainly focusing on the internal logistics of case-specific scenarios (Knoll, Reinhart and Prüglmeier, 2019; Knoll, Waldmann and Reinhart, 2019). Other authors developed a process mining system for determining the root causes of quality problems in a supply chain network (Lau et al., 2009). Based on daily captured logistic data, the authors fine-tuned configuration parameters to improve operational performance. Process mining is also extended with alternative or related techniques, including prediction techniques (Gunnarsson, van den Broucke and De Weerdt, 2019) and agent based modelling (Bemthuis et. al., 2020). These studies indicate a rich spectrum of use cases that can be considered when developing data-driven logistics applications.

4.5 Interoperability

There are relevant related studies in the logistics domain that address the interoperability challenges and the need for standardization. On a high abstraction level, the interoperability issues are addressed in the four levels of big data interoperability (Singh and van Sinderen, 2016). More specifically, the study of Lont et al. (2018) shows how different systems and devices can be linked to the data model of OTM, eliminating certain interoperability issues. Other studies emphasize the complexity of monitoring logistic processes (Cabanillas et al., 2013; Wang et al., 2014). The authors pinpoint the importance of new research, novel contributions on discretizing, aggregating, and correlating events in a way that the overall business process can be better traced. This work emphasizes that further research should be done on improving the quality of the event log data by including a reconciliation of the data. This strengthens the ideas put forward in this PDEng thesis. When event data are aggregated from different systems to monitor and analyse logistics processes, interoperability, data loss, and data quality issues are common challenges. Existing approaches aim to increase the accuracy of analytical techniques despite noisy data. Consequently, various tools and algorithms have been built in process mining tools to eliminate the effect of noisy data and determine the actual control-flow of a process. However, as logistic event data are typically complex, dynamic, and heterogenous, it remains challenging to generalize their results (Intayoad and Becker, 2018). More precisely, much of the current literature pays little attention to unified standards and logistic process definitions. The OTM provides such a standard for exchanging and sharing logistic data. In the position paper of Piest et. al. (2021), which will be discussed in **Section 4.8,** the idea and believe is introduced that the usage of the OTM, in addition to addressing (some) interoperability issues, can provide a promising foundation for a more unified implementation of data-driven practices in the logistics domain and its heterogeneous environment. The results and findings from experimental development are incorporated and **Section 6.2**.

4.6 Artificial intelligence and branches

The research topics AI and RL are briefly introduced in **Chapter 1**. This section extends the introduction and summarizes some related work in logistics. The term AI can be traced back to the 1950s and was first introduced by John McCarthy. AI research has resulted in an extensive body of knowledge and its branches, including rule-based AI, statistics, OR, ML, and DL represent an enormous knowledge base. The standard work of Russell and Norvig (2002) is selected as the theoretical foundation for this research. In their work Artificial Intelligence: A Modern Approach AI is defined as “intelligent entities that mimic cognitive functions” (Russell and Norvig, 2002). The aim of AI is to realize an autonomous system that can interact within its environment without human involvement. This often implies replacement of human intelligence by machine intelligence or execute formerly manual tasks using automation or robots without human intervention. Most successful AI developments in the last decade revolve around the DL paradigm. More recently, research also identified RL as an upcoming trend in AI (Hao, 2019). With RL an agent is trained using punishments and rewards, much like how humans learn in the real world. RL gained momentum in October 2015, when DeepMind’s AlphaGo defeated the world champion in a game of Go. Whereas supervised and unsupervised learning have been extensively researched, RL has attracted attention only recently. Literature connecting RL to practice, that goes beyond games towards an actual implementation in logistics, is however very scarce (Gemmink, 2019).

Currently, much research focuses on combining different data-driven approaches and techniques. For example, Mes and van Heeswijk (2020) compare the performance of two traditional Operations Research (OR) heuristics with RL implementations for automated logistics decision-making in a serious game setting. Most work that has been done concerning the use of (deep) RL for logistic applications is focusing on dynamic routing of robots, vehicles, and AGVs (e.g., Zhang et. al., 2020; Joe and Lau, 2020), item picking and placing by intelligent robots (e.g., Tanaka et. al., 2020), real-time order dispatching (e.g., Malus, Kozjek and Vrabič, 2020), and inventory management (e.g., Subramaniam and Gosavi, 2004; Sui, Gosavi and Lin, 2010). Research using ML and (deep) RL approaches for tackling hard combinatorial optimization problems are emerging (e.g., traveling salesman problem, combining neural combinatorial optimization with RL) (Bello et. al., 2016). Bai et al. (2021) review hybrid methods that are combining analytical techniques with ML tools in addressing the VRP and discuss the emerging research in regard to ML assisted VRP modelling and optimization. Bengio, Lodi and Prouvost (2020) surveyed attempts to combine approaches to leverage ML to solve combinatorial optimization problems and propose a methodology to integrate approaches. Combining traditional and modern approaches and exploring ensembles of models is a current topic of interest for scientific research and experimental development. Furthermore, Federated Learning (FL) is considered to be a promising new research topic. This topic is however not explored in this research project and deemed to future research.

4.7 Performance measurement and KPIs

Measuring performance of organizations is widely studied and reviewed by several authors (e.g., Folan and Browne, 2005; Domingues, Reis and Macário, 2015). Ren et. al. (2006) developed a framework for supply chain performance management based on the renowned supply chain operations reference model. Lemghari, Okar and Sarsri (2018) demonstrate the use of this approach in a case study in the automotive industry. Doumeingts, Clave and Ducq (1995) use the ECOGRAI model to design and implement performance measurement systems for industrial organizations. Abdelkabir, Abdellah and Bouayad (2012) use ECOGRAI together with the balanced scorecard to measure the performance of logistics processes. Kucukaltan, Irani and Aktas (2016) developed a decision support model for identification and prioritization of KPIs in the logistics industry. Dalmolen et. al. (2013) developed a framework to measure the Overall Effectiveness of Transportation (OTE). This framework measures the performance of transportation and is implemented in a BI dashboard prototype at an LSP. The underlying work of Iankoulova (2012) provides an extensive overview of KPIs that are relevant for this research. Furthermore, concerning KPIs to measure the impact of IT adoption, an interesting model is found for measuring and realizing the value of BI of Crossland and Smith (2008). Their extension of the original process model of Soh and Markus (1995) and later Marshall et al. (2004) visualizes the required steps to realize value from BI initiatives. The model contains IT related processes for IT alignment, IT conversion, and IT use, and emphasizes the importance of a competitive process to improve organizational performance and a benefits realization management process to capture the actual value. The IT alignment process starts with a strategic imperative, resulting in management appreciation and identification of needs and opportunities. Next, IT expenditures are the starting point for the IT conversion process and realization of IT assets. This conversion process requires IT involvement and management. When the developed IT assets are used, their impact depends on appropriate use. Inappropriate use will result in negative impact. Moving to the competitive process and the environment in which IT impacts organizational performance, the users need to develop a competitive process. Here, business and IT alignment is essential. In the last process step, benefits realization management is positioned to measure and monitor actual value realized. The extended process model is adopted and incorporated to develop the implementation guidelines and supporting performance measurement framework.

4.8 Earlier and related work

As introduced earlier, this research continues the work done in the research project Synchromodal IT. This early work illustrates a typical usage scenario in the logistics industry, in which automated retrieval and processing of multiple streaming open data sources improves the operational performance. The developed enterprise architecture models, prototype, and common data model described in Bol Raap et. al. (2016) served as a starting point for the development of a CLDM, schema matcher, and related reference architecture in the ALM project. Earlier work regarding schema matching resulted in a reference architecture for IA-driven schema matching (Piest et. al., 2020). Here, the CLDM is used to run experiments using a machine learning approach and IA. The results are incorporated in the project report (Piest and Iacob, 2021) and illustrated research posters in **Appendix C**. A high-level architecture for the industry platform is proposed in earlier work (Piest, 2019), that will be further introduced and discussed in **Chapter 6**, and aligned to become part of the Federated Data Sharing Infrastructure for the Dutch logistics industry to achieve the envisioned impact for a broader group of SMEs (Bastiaansen et. al., 2020; Piest, De Alencar Silva and Bukhsh, 2022).

The experimental use of the OTM is evaluated for process mining in logistics in earlier work by Piest et. al. (2021). The main idea put forward is that the OTM's data model can be effectively used for unified storage, integration, interoperability, and querying of logistic event data. An informal conceptual mapping study is conducted to determine whether the basic requirements for process mining can be fulfilled. More specifically, the data model of the OTM is mapped to a generic event log structure. Based on a step-by-step walkthrough, it is demonstrated how the OTM data model can be used to extract event data and create an event log. The event data are imported in a process mining tool to generate a process model. Despite its simplicity and limitations, it provides a common ground for solving interoperability issues related to process mining in heterogeneous environments using industry standards, specifically the OTM, and offers practitioners a dedicated, but generalizable, process model and approach to develop process mining applications. The results and insights from this informal conceptual mapping study formed the basis to develop the industry platform for data-driven logistics and explore broader use of the OTM for data-driven applications. This approach will be further elaborated in **Section 6.2**.

Some related work regarding AI and RL exists. Rabe and Dross (2016) developed an interesting single-agent decision support system architecture for logistics. However this architecture has similarities, it does not support model re-use, nor it uses standard data models, such as OTM, and relies on data-driven discrete-event simulation models. More recently and specifically, the work of Gemmink (2019) will be continued, in which a RL agent was developed and tested that is able to solve (a part of) the product allocation problem (i.e., “slotting”) for the Albert Heijn warehouses. The agent successfully learned how to allocate products according to the requirements prioritized by the company. Based on the concept of IA, warehouse employees were able to use the agent and increase their slotting performance. The model was tested in an experimental setting and validated using expert opinions. Experiments led to a deeper understanding of where (i.e., in which business processes) and how to use such a RL agent. Furthermore, the performance of the RL agent for a mid-size slotting problem was encouraging. The template agent and developed method for RL-driven business process re-engineering will be used to develop the implementation guidelines and re-usable agents.

4.9 Summary and conclusion

Reviewing literature adds a theoretical perspective to data use and technology adoption in SMEs. Research about enterprise architecture in SMEs presents both a theoretical and practical approach with mapping to the ArchiMate specification. When it comes to data-driven approaches, there are various options to consider, and many examples exist in literature with illustrative applications in transportation and logistics. Data analytics and -mining techniques are widely available, but methods require technical knowledge. The barriers and challenges that SMEs can experience are identified and simplified approaches are developed for SMEs. These can be related to the industry survey results. Process mining is explored next to data mining and offers much potential to discover process variations and analyse real-time event data. Related BI approaches provide a solid foundation to measure operational performance and provide a starting point for developing implementation guidelines and adoption framework. Extending introduced AI and RL approaches, various applications are present in literature. Supervised learning and unsupervised learning seem matured. RL is predominantly used in warehouse context and modern robotics. Current research is combining traditional and modern approaches, for example blending OR techniques with RL. Furthermore, FL is considered to be a promising research topic that also connects well with initiatives in the Topsector Logistiek. Based on the literature review, a collective approach is discovered and adopted for this research project. In addition, related and earlier work are summarized and synthesized.

DESIGN METHODOLOGY

5 Design methodology

This chapter describes the design methodology and discusses the used methods and techniques. **Section 5.1** provides an overview of the DSRM. **Section 5.2** discusses the application of methods and techniques as part of the DSRM. **Section 5.3** provides an overview of the ADR method. **Section 5.4** discusses the application of ADR. **Section 5.5** describes the selected methods, approaches, and tools from the PDEng program. **Section 5.6** presents the blended research, design and development approach that is used based on DSRM, ADR, and selected methods, approaches, and tools from the PDEng program. **Section 5.7** summarizes and concludes the chapter. This chapter incorporates related work from published articles.[22]

5.1 Overview of the DSRM

As introduced in **Section 1.3**, the DSRM of Peffers et. al. (2007) is adopted as the main design methodology for this research project. The DSRM prescribes six different phases, as shown in **Figure 16**, which are used for the R&D of the industry platform and implementation guidelines.

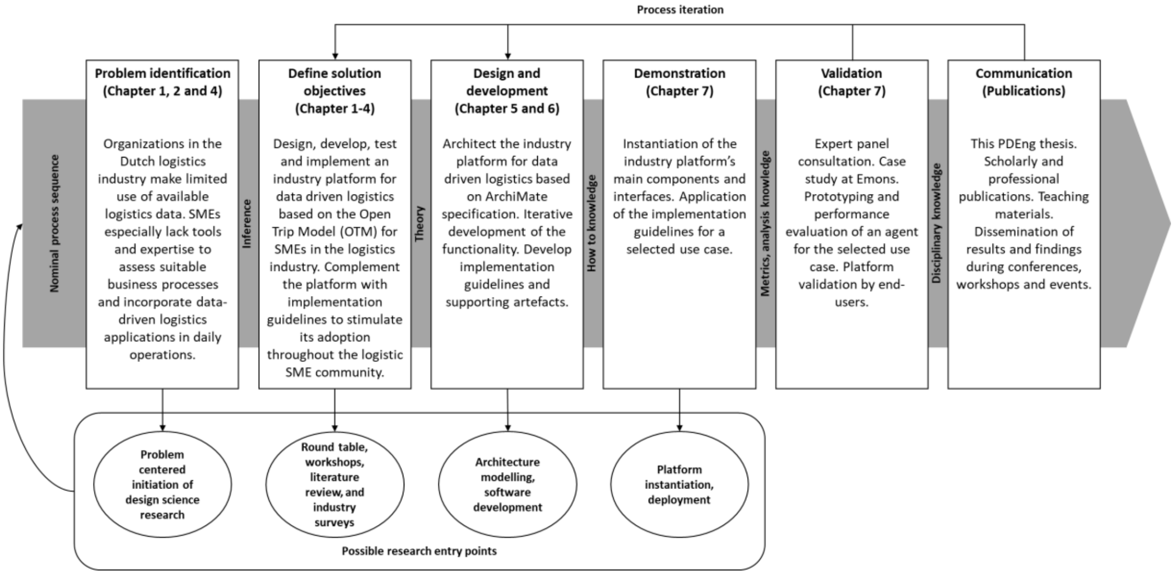

Figure 16: Application of the DSRM (adapted based on Peffers et. al., 2007).

The DSRM is an established design methodology and used in many related research projects. More specifically, it contributed to the successful development, demonstration, and evaluation of similar platform architectures (Bol Raap et. al., 2016; Iacob et. al., 2019; Bemthuis et. al., 2020; Piest et. al., 2020; Piest and Iacob, 2020).

5.2 Application of the DSRM

This section explains how the different DSRM phases are applied.

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[22] **Section 5.1 and 5.2** contain parts of the research paper (Piest et. al., 2021). **Section 5.3-5.6** are added to extend and integrate earlier work.

Subsection 5.2.1 covers the problem identification and solution objectives phases	The **6 DSRM phases** are mapped to the PDEng thesis structure and appendices
Subsection 5.2.2 comprises the design and development phase	
Subsection 5.2.3 contains the demonstration and validation phases	
Subsection 5.2.4 highlights the communication phase	

5.2.1 Problem identification and solution objectives

The problem identification is mainly covered by **Chapter 1**, where the industrial context is narrowed down in a problem statement, **Chapter 2**, which describes the research project, and **Chapter 4**, which provides a theoretical perspective. More specifically, the problem statement and solution objectives are described in **Subsection 1.2.1**. **Section 1.3** elaborates how problem centred design science research is conducted based on the DSRM. **Chapter 2** connects the design project to the solution objectives as part of a wider research context. **Chapter 3** focuses on the identification of stakeholders, their goals, and platform requirements. Additionally, use cases are identified based on the roundtable discussion (**Appendix D**), workshops with consortium partners and further refined using stakeholder interaction and the adoption method and process described by Gemmink (2019). Wider contextual analysis is based on industry surveys (InfoResult, 2018; Evofenedex, TLN and Beurtvaartadres, 2019; InfoResult, 2021) and a literature review regarding data use and technology adoption in SMEs by Bernaert et. al. (2014). **Chapter 4** provides an overview of relevant related work and suitable data-driven approaches that can be considered to achieve the solution objectives. The literature review process is described in **Section 4.1**.

5.2.2 Design and development

Building on the problem investigation and the solution objectives phases, the design and development phase is described and discussed in **Chapter 5 and 6**. The design methodology and the application of methods, approaches, and tools from the PDEng program are described in this chapter. **Chapter 6** documents the design and development of the industry platform architecture, elaborating the functional components and presenting several design artefacts, and supporting implementation guidelines and adoption framework. The actual platform development work is divided into three development cycles, which will be described in more detail in **Section 5.5**. The industry platform functions as a testbed to conduct multiple experiments with different algorithms in order to get a better understanding about their advantages and drawbacks in terms of performance and ease of use, starting with basic algorithms and scaling up from there.

5.2.3 Demonstration and validation

Chapter 7 covers the demonstration and validation phases. First, the industry platform concept is verified using expert panel consultation. Then, the industry platform is instantiated for testing and the results and findings are documented. Following the development cycles, the validation activities in these phases are also organized into three implementation cycles. The feedback from each cycle will be formalized using ADR and incorporated in the next development cycle in an agile fashion. Next, empirical research is conducted at Emons, a family owned Dutch LSP to validate the industry platform and supporting implementation guidelines. Case-based research is used for the experimental development of agents and selected use cases.

5.2.4 Communication

Finally, the communication phase is covered by this PDEng thesis and the related publications in **Appendix A**. Broader dissemination will be facilitated through (online) teaching materials, workshops, and industry events as described in **Section 2.5, Section 2.6,** and **Section 7.5**.

5.3 Overview of the ADR method

This section describes the ADR method that is used for this research project.

Subsection 5.3.1 describes the four stages of the ADR
Subsection 5.3.2 discusses two generic schemes that are used for applying ADR

The **4 stages of ADR** are discussed

5.3.1 Stages of the ADR method

ADR is defined by Sein et. al. (2011) as “a research method for generating prescriptive design knowledge through building and evaluating ensemble IT artefacts in an organizational setting”. The ADR method proposed by Sein et. al. (2011) consists of the following four stages with its own principles: 1) problem formulation, 2) Building, Intervention and Evaluation (BIE), 3) reflection and learning, and 4) formalization of learning as displayed in **Figure 17**.

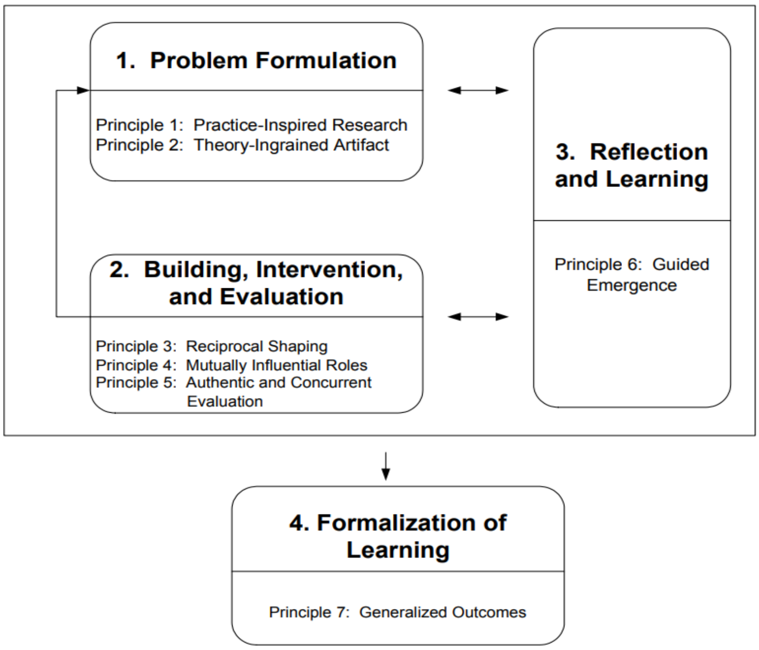


Figure 17: Overview of the action design research method (image: Sein et. al., 2011).

5.3.2 Generic schemes for BIE

The ADR method can be applied via a generic scheme using either IT dominant BIE or organization dominant BIE, shown in **Figure 18**.

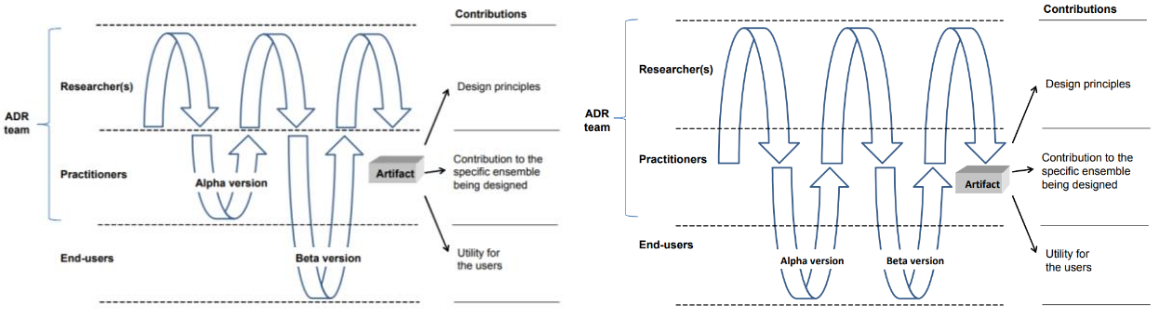


Figure 18: Generic schemes for IT- (left) and organization dominant BIE (right) (image: Sein et. al., 2011).

According to its authors, IT dominant BIE best suits “ADR efforts that emphasize creating an innovative technological design at the outset” (Sein et. al., 2011). Here, the initial artefact has no impact to the end-user organization and feedback of practitioners is translated into an improved artefact that can gradually be introduced to end-users and lead to the final design of the ensembled artefact. Organizational dominant BIE is more suited for “ADR efforts to generate design knowledge where the primary source of innovation is organizational intervention” and “the ADR team challenges both end-users and practitioners existing ideas and assumptions about the artefact’s specific use context to create and improve the design” (Sein et. al., 2011).

5.4 Application of the ADR method

ADR is used to refine the development and validation phases in the DSRM and facilitate iterative development. The problem formulation stage can be related to the first phase of the DSRM. Next, the IT dominant BIE is applied to deliver the industry platform, initially without intervening current processes and end-users. Based on the results of the first iteration, end-users can be involved in either the second or third iteration when the industry platform’s functionality is working according to performance standards. The implementation guidelines will follow the organization dominant BIE and end-users will be directly involved. Based on testing and validation with consortium partners, the implementation guidelines will be refined.

5.5 Selected methods, approaches, and tools

This section describes the selected methods, approaches, and tools from the PDEng program. Although this design project does not make formal use of system engineering processes or application standards, the V-model, as shown in **Figure 19**, is used to map the DSRM and ADR to the structure the sections of **Chapter 6 and 7** in a logical sequence.

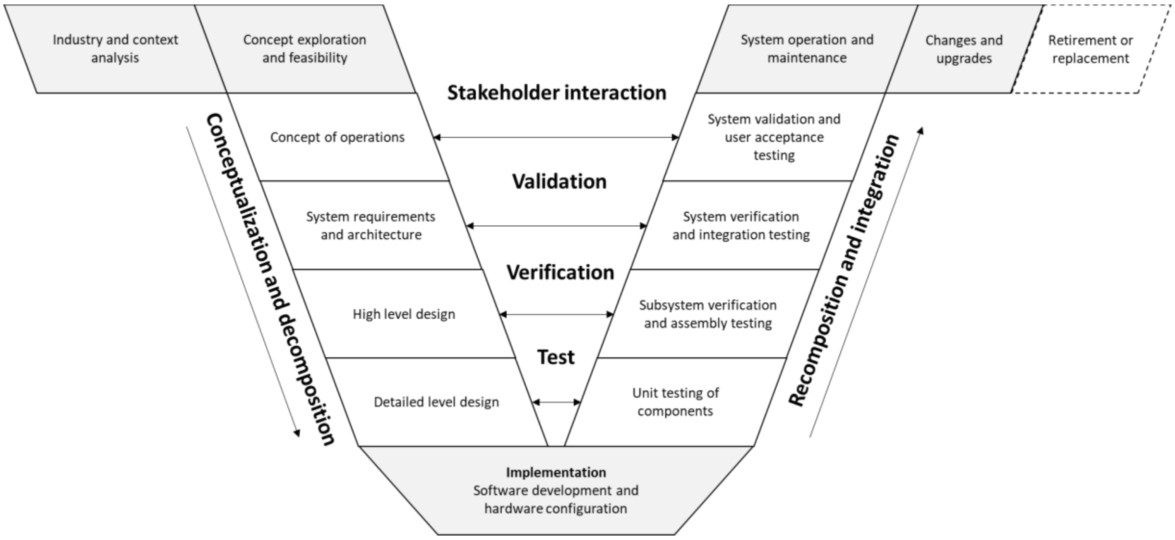


Figure 19: V-model (adapted based on PDEng course materials).

The industrial context is introduced in **Chapter 1** and the research context is introduced in **Chapter 2**. The context is further analysed in **Chapter 3** and a programme of requirements is created for the industry platform. Special attention is given to safety and risk management and ethical design aspects. Extending the main research and design focus, the lifecycle is analysed and future scenarios for societal embedding of the design are elaborated. Related concepts are explored from a theoretical perspective in **Chapter 4**. In earlier work, the feasibility of the OTM is evaluated for process mining. This PDEng thesis extends this work by exploring the use of the OTM for broader analytical purposes. **Chapter 6** will then cover the conceptualization and decomposition. First, the results of systems thinking activities are presented. Second, a layered architecture is presented to support the envisioned concept of operations in the form of a business process and positions the main components and interfaces. Next, a detailed industry platform architecture is described, and detailed designs are presented. Then, the actual implementation of the industry platform is discussed. In **Chapter 7**, the results of stakeholder interaction, industry platform testing, and validation by stakeholders is documented to illustrate the recomposition and integration of the industry platform.

5.6 Blended research, design, and development

The DSRM is the main methodology used to guide the research and design processes. The DSRM does not prescribe specific methods and tools for each stage. It highlights different entry points for research and is predominantly aimed at design science research. However the DSRM mentioned the presence of iterative processes, the model does not make these processes explicit. Therefore, parts of the ADR are blended in to create an iterative approach, incorporate stakeholder interaction during the development and implementation processes, and foster learning and formalization of design principles in the form of implementation guidelines. Furthermore, the DRSM does not cover the full lifecycle, incorporating the use, maintenance, and disposition. Systems engineering approaches, specifically the V-model, addresses the full lifecycle. The downside of the V-model is that it tends to describe everything upfront and is less suitable for innovation projects and experimental development. Moreover, the systems engineering approach is focused on hardware and software of integrated physical products. Initially, the focus will be on developing the industry platform's functionality and features. After establishment of the core industry platform functionalities, separate cycles for AI will become the focus of development. Agile principles for software development focus on releasing working functionality and can speed up the delivery of features during each ADR iteration. Therefore, each iteration contains a retrospect to evaluate the artefact, process and formalize learnings. Based on systematic approach of the V-model and inspired by the Agile V-Model (AIoT Playbook, 2022), a blended approach is created and presented in **Figure 20**.

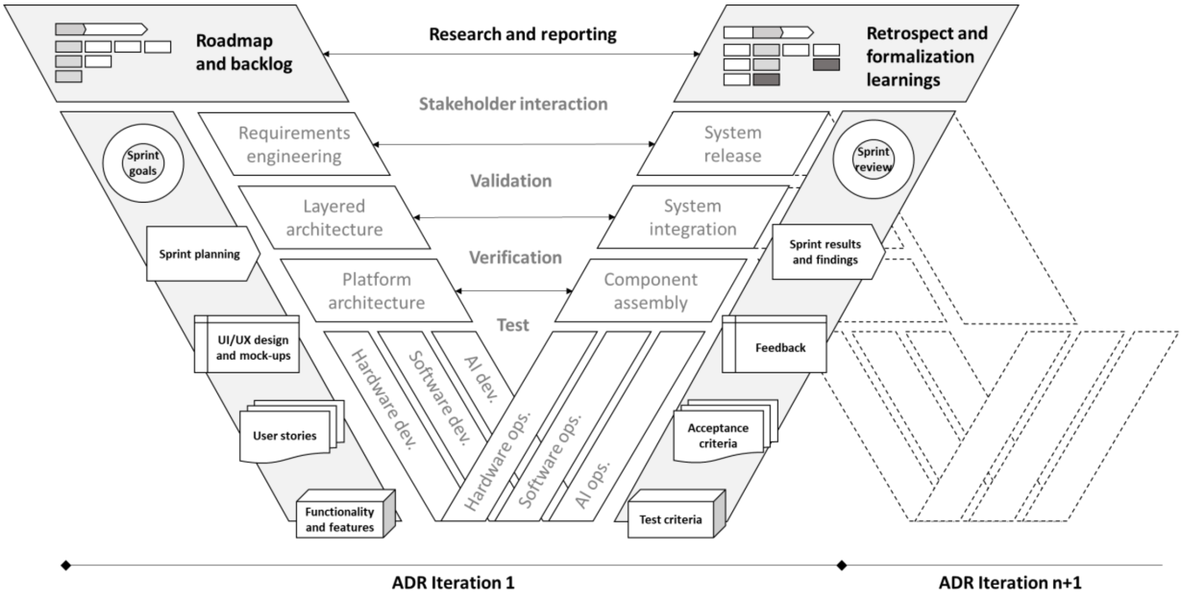


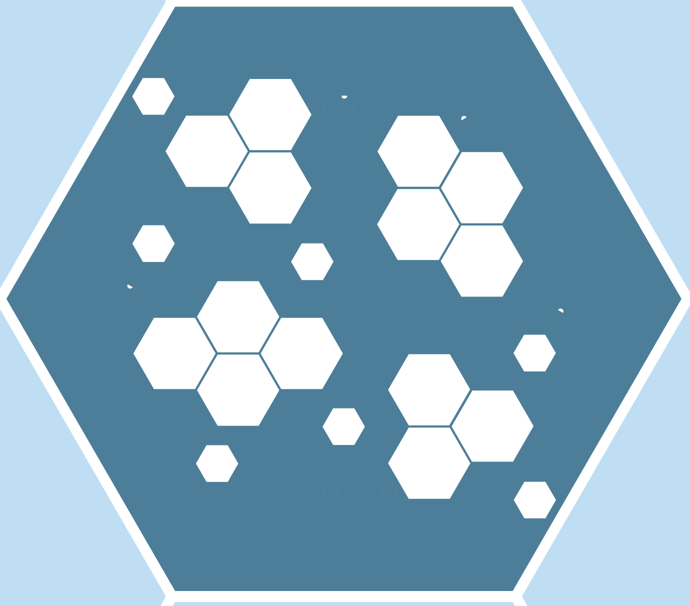
Figure 20: Agile V-Model (Adapted from AIoT Playbook, 2022).

The insights and feedback of each ADR iteration can be incorporated in the next iteration or moved to the backlog. A DevOps approach for continuous development, testing, integration, and improvement can be incorporated in a later stage to support lifecycle management.

5.7 Summary and conclusion

The industry platform and implementation guidelines are designed based on the DSRM. The ADR is incorporated to facilitate stakeholder interaction and formalize the learning and evaluation process. The Agile V-model is adopted to blend in systematic systems engineering approaches and agile practices to facilitate short iterations.

DESIGN AND DEVELOPMENT



6 Design and development

This chapter describes the design and development of the industry platform architecture and its main components and interfaces. **Section 6.1** starts by summarizing design decisions and selected tools. **Section 6.2** presents the results of systems thinking activities. **Section 6.3** outlines and describes the system architecture. **Section 6.4** describes the industry platform development iterations and main results. **Section 6.5** presents the implementation guidelines and adoption framework that are developed to complement the industry platform. **Section 6.6** summarizes and concludes the chapter. This chapter is an extension and synthesis of published articles and individual course work from the PDEng program.[23]

6.1 Design decisions and selected tools

Based on the design methodology, described in **Chapter 5**, several design decisions are made. The first design decision is that the industry platform should provide a growth path towards data-driven logistics based on available data in SMEs, focusing on advancing data usage, and not replacing existing reporting solutions. Users in SMEs should be able to instantly start using the industry platform via a non-invasive web interface and gradually adopt data-driven logistics approaches. The second design decision is the focus on the OTM to standardize data-driven applications and develop building blocks based on the federative data sharing infrastructure. The use of iSHARE is foreseen, but not implemented. In a later stage, the industry platform can be IDS certified. The third design decision is that the industry platform will primarily have a research focus. Interoperability is part of the design. However automatic schema matching is not included. The fourth design decision is that end-users will not be provided access to development services. The first development cycles will focus on developing the main components and interfaces. Subject matter experts will be in the lead and test the industry platform. End-users will be involved to validate the implementation guidelines and results. Development of agents by end-users is foreseen in a later stage. The fifth design decision is that the focus will first be on supporting LSPs via the industry platform. LSPs are considered to be the main beneficiary. Based on the knowledge and preferences of the research and development team, which is introduced in **Subsection 6.4.1**, decisions are made regarding the use of methods and tools. The ArchiMate language and specification is selected for architecture modelling (The Open Group, 2016). The Entity Relation (ER) diagram notation is selected to model the OTM. Concerning software engineering, modern front-end and back-end technologies are selected based knowledge of the development team and preference for open-source software with international

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[23] **Section 6.2** contains parts of the doctoral consortium paper (Piest, 2019), the position paper (Piest et. al., 2021) and individual course work in the PDEng. **Section 6.3-6.5** are related to the research paper (Piest et. al., 2021). **Subsection 7.5.2** is incorporated in a conference paper (Piest, Iacob, and Wouterse, 2022).

communities and online resources. Front-end technologies include React[24] and NodeJS[25]. Algorithms are developed in Python[26]. PostgreSQL[27] is selected as open-source relational database. Kubernetes[28] is selected to design a scalable infrastructure. Microsoft Azure[29] is selected for its infrastructure services and the large installed base in the logistics industry.

6.2 Systems thinking

This section presents the results of systems thinking activities.

Subsection 6.2.1 contains the results of conceptualization activities	**Step 3 in DSRM**
Subsection 6.2.2 explores the use of OTM for data-driven applications	Design
Subsection 6.2.3 documents the process of solution space exploration	

6.2.1 Conceptualization

In the doctoral research paper (Piest, 2019), a context diagram is used to position the industry platform in relation to its envisioned users, stakeholders, and data sources in logistics. **Figure 21** shows the high-level concept and application of the concept of IA.

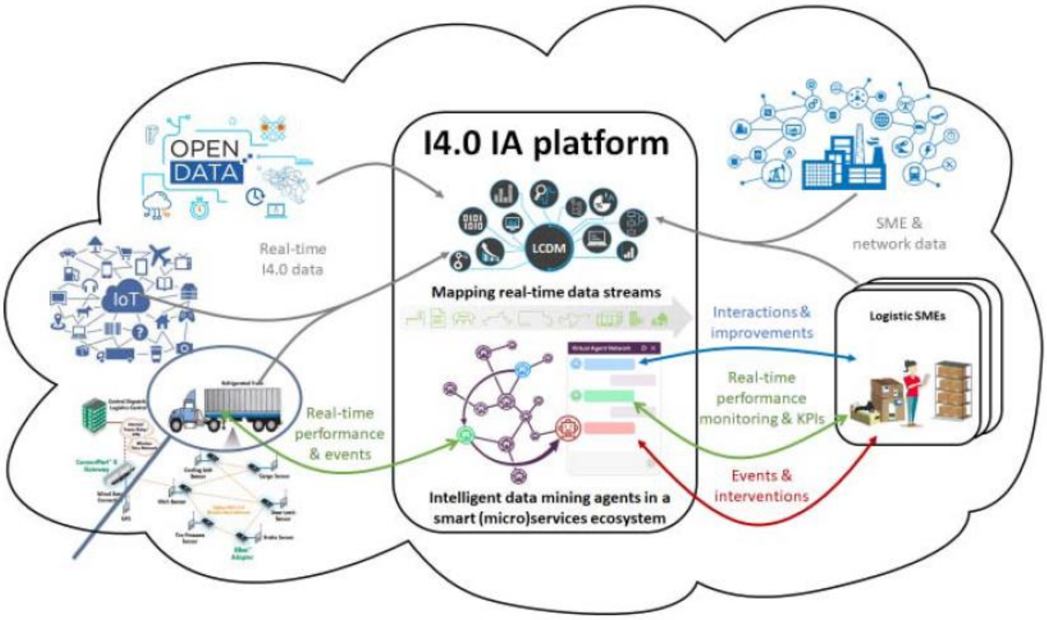

Figure 21: Conceptualization of the industry platform and application of IA (image: Piest, 2019).

The industry platform is essentially a multi-agent system that supports the harvesting of transactional and real-time event data from different sources (e.g., on-board computers, IoT and open data providers). This real-time data are put in context using internal data from SMEs and network data. The industry platform processes data and transforms data into a unified model, the OTM. The

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[24] https://reactjs.org/
[25] https://nodejs.org/en/
[26] https://www.python.org/
[27] https://www.postgresql.org/
[28] https://kubernetes.io/
[29] https://azure.microsoft.com/en-us/

intelligent agents then apply common data mining algorithms and interact with users in operational logistics environments at logistic SMEs based on IA. The user has access to real-time performance insights based on KPIs, is notified of events, and can intervene where needed and possible.

Based on individual course work during the PDEng program, the context diagram is elaborated using an extended version of the nine-window diagram (Gadd, 2011) to analyse past, present, and future capabilities from a system engineering perspective. The result is shown in **Table 8**.

Past super systems Integrated business planning, sales & operations planning, track & trace, portal, web shop, expert and recommender systems	**Super systems** Collaborative planning, forecasting & replenishment, marketplaces, open data and linked data, IoT platforms	**Future super systems** Physical internet, connected and autonomous transport, self-organizing logistic systems
Past systems of interest Desktop applications, ERP, TMS, WMS, DMS, finance, customs, Excel, reporting, data warehouse	**Systems of interest** Office 365 (O365), mobile apps, platforms, APS, specialized inventory and optimization systems, BI/analytics	**Future systems of interest** CPS (of systems), Industrial data spaces, blockchain, data science and AI platforms
Past subsystems/components Server(s), personal computers, local area networks, printers, scanners, on-board computers, GPS, Bluetooth	**Subsystems/components** Virtualization, hybrid cloud computing, AGVs, multi-device, sensors/tags, microcomputers, mobile network, 4G	**Future subsystems** Serverless computing, modern robotics (e.g., drones, pick robots), quantum computing, 5G
Past interfaces EDI connections, value adding networks, file exchange, database connections	**Interfaces** Middleware, APIs, micro services, integration platform, real-time event streaming	**Future interfaces** Conversational interfaces (speech) and computer vision
Past data use Excel reporting, VBA optimization (OR), BI, rule-based AI (heuristics), data mining and (un-)supervised ML	**Data use** Big data analytics, reinforcement learning, process mining, business process management and robotic process automation	**Future data use** Deep reinforcement learning, federated ML, cognitive automation

Table 8: Extended version of the nine-window diagram (adapted from Gadd, 2011).

The windows related to the past summarize established technologies and legacy systems. Most IT run on desktop computers and standardized systems that are deployed on-premises. ERP and WMS are mostly used by manufacturers, wholesalers and retailers owning or selling goods. TMS and FMS are used by transport operators and connected to on-board computers via GPS. Logistics service provides use additional specialized customs software. These approaches together are established forms of IT in logistics. The past super systems show the developments that leading parties and early adopters deployed. The windows related to the present highlights the current dominant usage of cloud systems, modern interfacing, and data processing technologies. Many organizations are migrating to O365 and start using PowerBI, apps and bots using robotic process automation. Specialized subsystems and interfacing products/platforms are used by leading and large organizations. Larger organizations in general have in-house IT and data analysts to connect systems, devices, and use data for data-driven logistics applications. Leading organizations migrated much of their on-premises applications to cloud infrastructures and leverage data in decision-making. The windows related to the future points out emerging technologies and experimental developments. These include, but are not limited to, CPS, industrial data spaces or blockchain applications related to connected assets and advanced data science and AI platforms. Underlying subsystems are partly developed, but not available on a large scale to support global supply chains. The adoption of autonomous technologies is restrained to indoor use, designated areas and not (yet) allowed in mixed traffic and/or the public environments. Systems are not replaced regularly and maintained for periods of 10–15 years. For the industry platform it is important to be able to interface with legacy systems. Excel is the number 1 tool for reporting and data analytics. Therefore, the envisioned system must be able to import data from spreadsheets to support the transition towards real-time data analytics using APIs.

6.2.2 Concept exploration

The OTM is an open-source, flexible data sharing model that contributes to uniform and consistent exchange of information across various information systems. The OTM is originally developed by Simacan, currently managed by SUTC, and its goal is to help logistics companies in the Netherlands share real-time logistic data efficiently (SUTC, 2019). The constructed data model of the OTM, as shown in **Figure 22**, is centred around event data and considers eight entities and four lifecycles. The OTM is designed to support the lifecycles related to logistics data. The life cycles of a transport order are planned, forecasted, actual, and realized. The four phases cover the creation, use, and archiving of data. Data disposal is not incorporated in the lifecycle. Entities are used to represent various objects within a logistic process (e.g., vehicles and locations). The data model contains static and dynamic entities. Static entities are location, vehicle, route, trip, constraint, sensor, shipment, and actor. Dynamic entities are incorporated as events. All dynamic behaviour of actors is modelled as (a series of) event(s) and can be related to shipments, trips, and routes. The order of these events indicates the workflow over time, and this is depicted by the lifecycle. This way, a trail of event data are created.

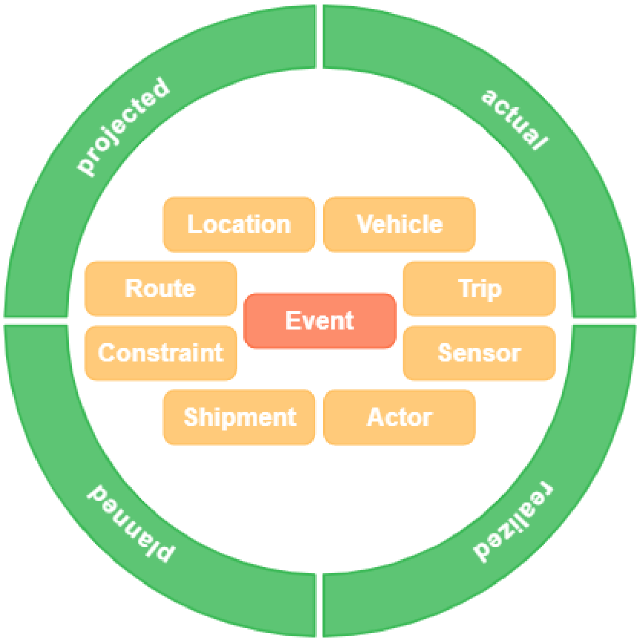


Figure 22: Version 5 of the OTM (image: opentripmodel.org).

Event data, together with related entities and the lifecycles, provide the foundation to develop data-driven applications, apply process mining techniques, use data for behavioural analysis, and performance management. In earlier work, discussed in **Section 4.8**, the use of the OTM for process mining is evaluated. **Figure 23** is based on version 4.2 of the OTM and shows how the minimal requirements for creating an event log can be satisfied.

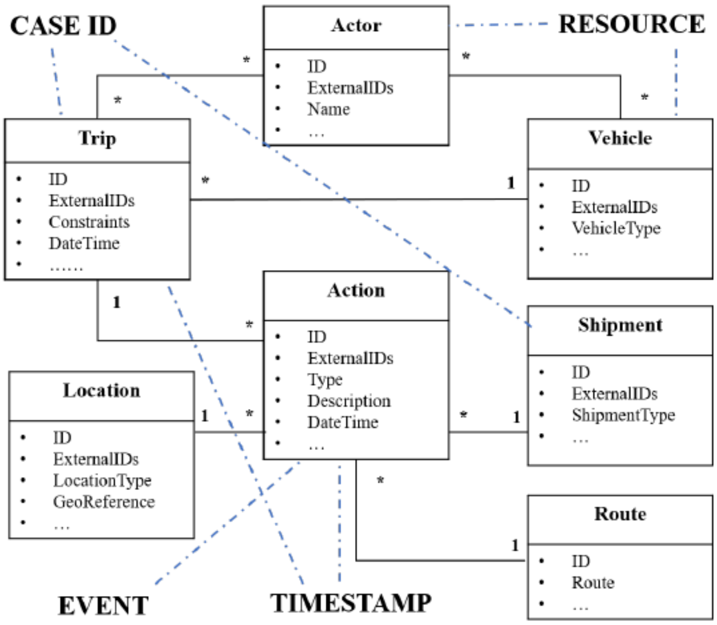


Figure 23: The OTM 4.2 and application of its data model for process mining (image: Piest 2021).

The lifecycle expresses the different phases in the transport process and enables different views on the operation (e.g., look ahead at events that have been planned, what is taking place right now or what has been realized). In terms of time scales, objects such as locations, vehicles, sensors, and actors are static and might change in some years due to relocation, selling a vehicle, replacing a sensor, or changing contacts. Shipments contain static elements and are linked to a planning of 1-3 days in the case of domestic road transport. In international multimodal transport, this can be weeks or months. Routes can be static when they are part of a fixed trade lane or preferred route to drive. Trips are more subject to the operational conditions, and underlying systems dynamics, and often are executed in 1 working day in the case of road transport.

6.2.3 Solution space exploration

Based on the analysis of the OTM and its lifecycles and time scales, systems thinking is applied to ideate possible use cases for data-driven logistics. **Figure 24** illustrates the initial results.

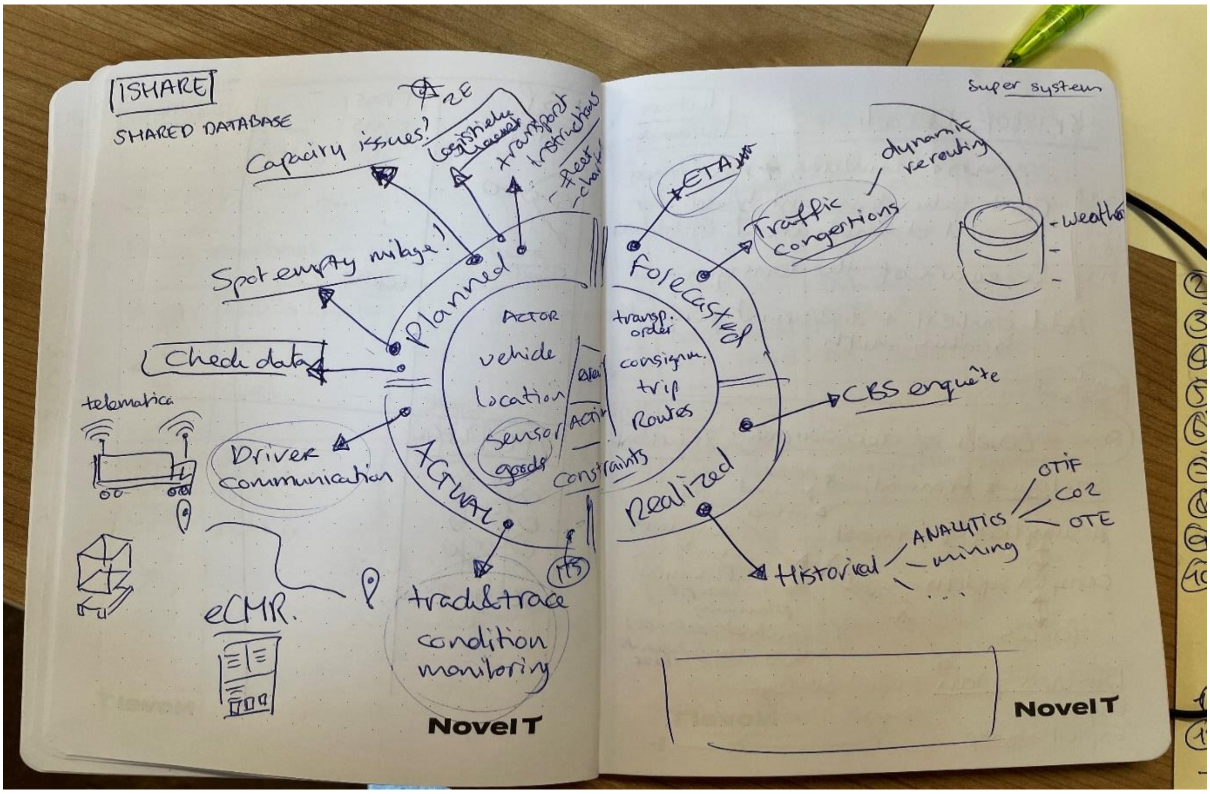


Figure 24: Application of life cycle and scales thinking based on the OTM.

In the drawing, the 4 lifecycles are mapped to different data analytics use cases and time scales. Planned transports combine different time scales (e.g., today, this week, this month). The data are dynamically gathered via communication with shippers and carriers. Peaks and demand spikes can be made visible based on data analytics. Capacity issues can be identified, and planners can search for shipments on spot markets or offer capacity to marketplaces. Based on historical data and planning, a forecast can be made to predict demand and capacity volumes. This can be done on a daily, weekly, monthly basis, but also real-time in transit using traffic and weather data, current positions, and detailed route data. Actual transport that is currently in transit can utilize real-time data for track and trace and condition monitoring. Typically, GPS and sensor data are shared via telematics, RFID, and IoT networks. Driver communication often follows pre-defined workflows and communication in terms of activities and status codes. Realized transport contain historical data over a longer period of time (e.g., weeks, months, years). This data can be used to analyse the past, calculating performance using KPIs (e.g., On Time In Full (OTIF), Carbon Emissions (CO_2), Operational Transport Effectiveness (OTE)), and make predictions about the future. Furthermore, the OTM is suitable for exchanging freight documents (e.g., eCMR) and is adopted by the CBS for the annual survey. Thus, the OTM offers a variety of opportunities to develop data-driven logistics applications.

6.3 System architecture

This section presents the system architecture for the industry platform.

Subsection 6.3.1 presents and describes the layered view of the industry platform	**Step 3 of DSRM**
Subsection 6.3.2 elaborates the concrete platform architecture	Design

6.3.1 Layered view

As introduced in **Section 6.1**, the industry platform architecture is modelled using the ArchiMate modelling language. **Figure 25** depicts the layered architecture for the industry platform for SMEs. The industry platform consists of the following components and interfaces:

1) Graphical User Interface (GUI) to access platform services: to provide SMEs access to the platform, manual input/import data and provide decision support. This facilitates users in SMEs to instantly start using the industry platform and available agents.
2) APIs to automate the data collection based on the OTM: the use of OTM by LSPs alleviates the problem of having to update the data sources manually. This increases the platform's interoperability and data usage on a broader scale with multiple actors.
3) OTM compliant database: The platform stores SME data based on the OTM specification which will be the basis to develop standardized agents.
4) Repository and development tool for testing multiple algorithms and perform (hyper)parameter tuning: provide software developers a tool that supports the development and testing of one specific or multiple algorithms, compare performance to identify the best performing ones for each type of decision problem and subsequently make re-usable agents available on the industry platform in a repository.
5) Infrastructure provisioning to run and monitor agents: this part of the industry platform supports system administrators with the automatic provisioning, management, execution, and monitoring of agents and will be connected to the platform's endpoints.

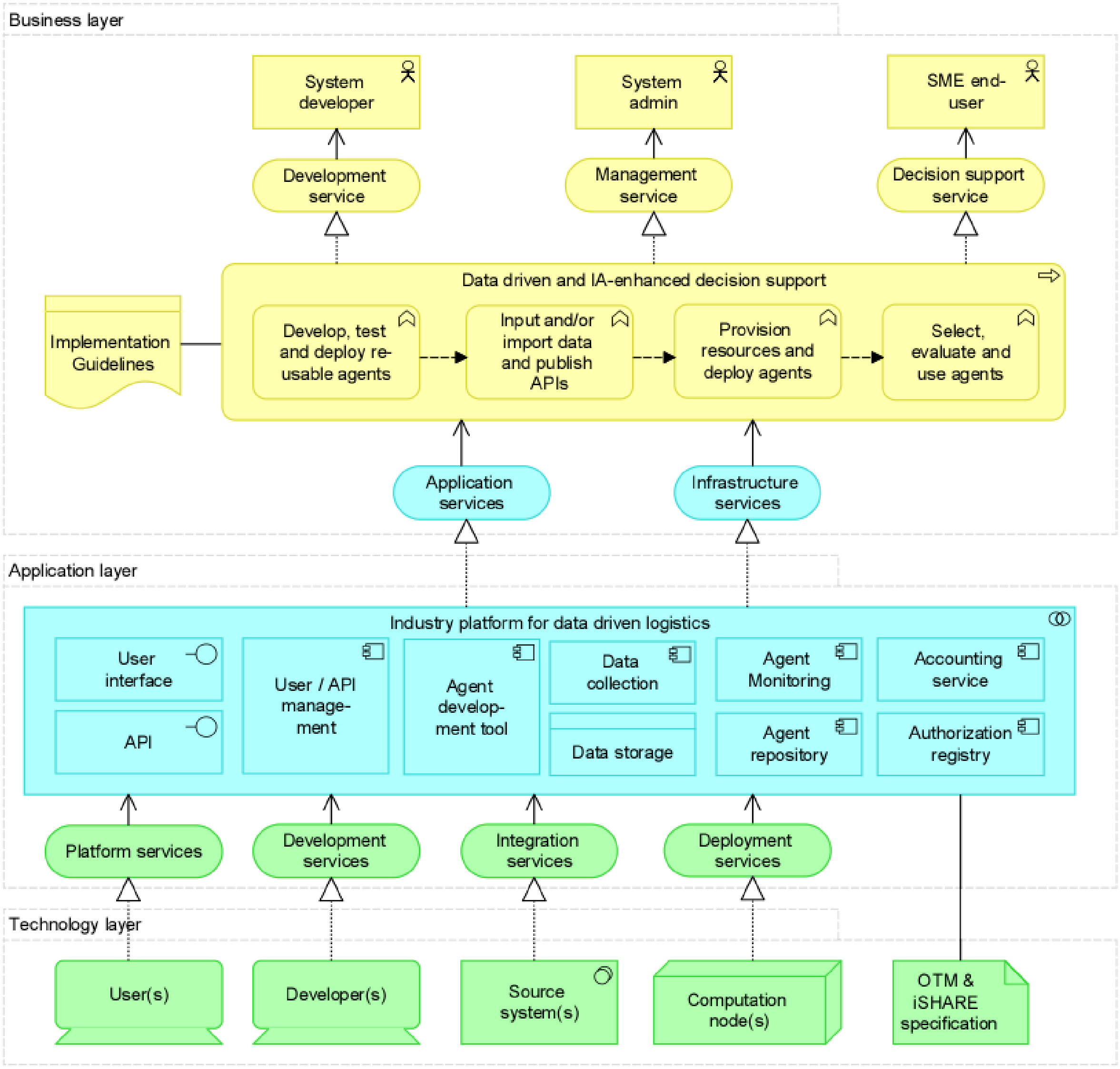


Figure 25: Layered view of the industry platform (adapted based on Piest et. al., 2021).

The layered view, presented in **Figure 25**, is kept on a high-level of abstraction in pursue of potential generalization and to illustrate the industry platform usage in regard to its main components and interfaces. The main functional components will be accompanied by implementation guidelines and are compliant with the OTM specification and iSHARE in a later stage.

6.3.2 Platform architecture

The concrete platform architecture that is instantiated, shown in **Figure 26**, is derived from the layered view shown in **Figure 25** from the perspective of the SME. It draws upon previous work regarding the development of distributed service platforms, pluggable (micro) services, and incorporates functional and non-functional requirements, in particular focusing on those specific for SME supply chains, including service models, application components and interfaces, data elements and concrete agents. At the very core of the architecture is the user of the system, the transport planner and/or business analyst, having access to a repository of intelligent agents that encapsulate the most common use cases. Based on stakeholder interaction the following use cases are selected:

dynamic (re-) planning, disruption handling, smart tendering for empty milage reduction, condition monitoring and predictive maintenance.

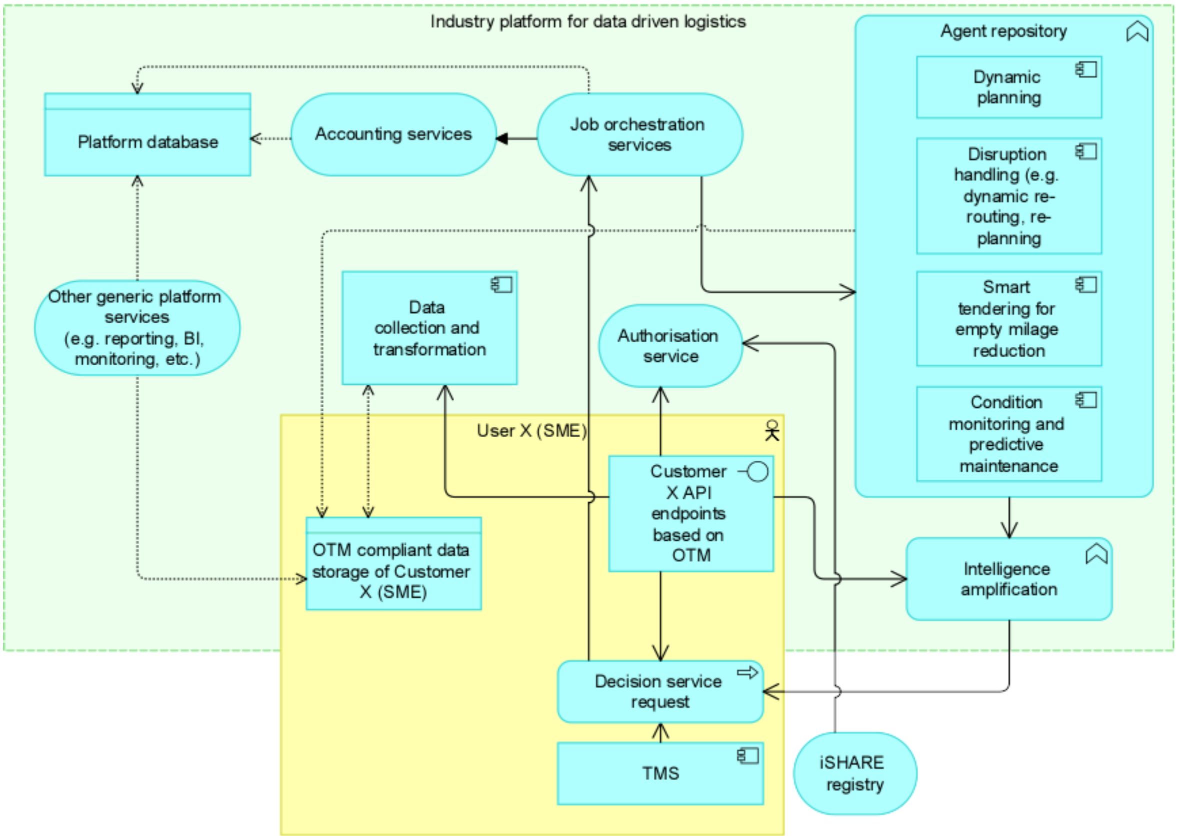


Figure 26: Architecture of the industry platform (adapted based on Piest et. al., 2021).

Developers create agents to support these use cases and can implement different types of agents. Next, the application of a simple reflex agent and more sophisticated learning agent are introduced. A simple reflex agent can be used to detect disruptions by constantly checking the environment and applying condition-action rules to assess whether planned shipments will be on time. Based on planned and actual status information, delays, events, and disruptions are detected by the agent and communicated to the user. The simple reflex agent can be extended to a goal based agent to automate (parts of) the decision-making. In the use case about smart tendering, a learning agent can be developed to observe the planning, measure the performance, and learn to search for trips that contain empty milage. Additionally, a learning agent can be developed to spot interesting lanes on marketplaces to reduce the empty milage based on learning goals. Using an advantage actor critic model, a critic assesses the learning process and results of state changes. Due to the fact that planning is subject to market dynamics, the agent must constantly adapt and retrain/-learn to meet the performance standards. Agents are made available to users via the repository and are based on the OTM. This way, agents can easily be re-used by SMEs. **Figure 27** presents the formal Entity Relation (ER) diagram that is created based on the OTM version 5.

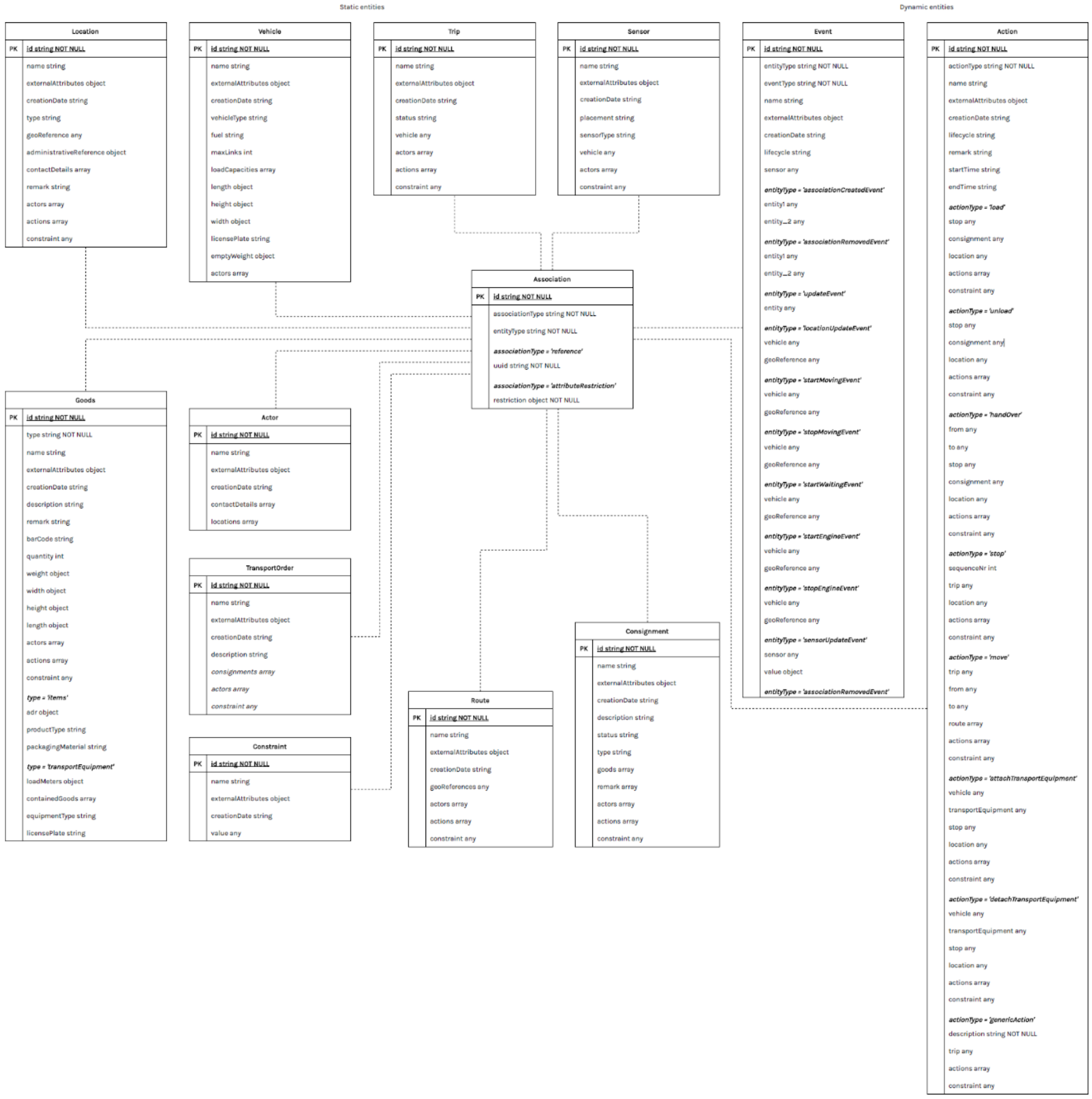


Figure 27: Entity relation diagram based on OTM version 5 (for illustration purposes).

The platform services should require minimal technical knowledge and supervision from the end-user and provide functionality based on the concept of IA. This way, the agents can support SMEs that are overwhelmed with data, and have limited resources to analyse it, by providing them with the ability to get insights in overall performance factors, estimating potential disruptions, and compensating for such disruptions through efficient and timely re-planning actions. Decision-making and problem solving can be initiated manually and automated by connecting available systems to the platform via its APIs. To achieve the identified goals and requirements, the industry platform architecture requires a scalable infrastructure, including job orchestration to dynamically provision and assign computation power to agents, and an agent repository containing different agents. The platform provides basic authorization services, foresees advanced data sharing based on iSHARE, and facilitates data exchange and storage based the OTM compliant APIs and data models. Additionally, the platform keeps track of service consumption, the usage of computational resources and provides other generic platform services (e.g., reporting, BI, monitoring) to facilitate broader data-driven approaches for decision support and problem solving. This way, the industry platform can cope with different levels of IT maturity and connect with available systems in SMEs.

6.4 Platform development

This section describes the industry platform development process based on IT dominant BIE.

Subsection 6.4.1 presents the research, design, and development team	**Step 3 of DSRM** Design & Development
Subsection 6.4.2 highlights the results of the design sessions	
Subsection 6.4.3 contains an overview of the development iterations	
Subsection 6.4.4 presents the user stories for development and testing	

6.4.1 Team

Table 9 presents the research, design, and development team that is formed to design and develop the industry platform.

Name	Organization	Team role
Jean Paul Sebastian Piest	University of Twente	Researcher, product owner and system architect
Martijn Gemmink	Bullit Digital	Front-end developer and data scientist
Bjorn Goossens	Bullit Digital	Back-end developer and infra-structure specialist
Corona Zschüsschen	Sjusjun	Illustrator
Niké Schuurmans	Niké Creatief	UI/UX Designer

Table 9: Industry platform research, design, and development team.

The researcher was in the lead and involved throughout the whole process together with both developers. The illustrator and UI/UX designer were mainly involved during the design of the industry platform. The researcher developed the initial idea, concepts, and high-level architecture related to the industry platform. Based on co-creation, the detailed designs were developed by the researcher and developers. The developers realized the industry platform functionality.

6.4.2 Design sessions

The development team collaborated with the illustrator and UI/UX designer to develop the name, logo, and identity for the industry platform. The URL officedog.ai was already registered by Martijn Gemmink. The idea behind this name is that SMEs can adopt an office dog that will act as a companion and can learn tricks. Design sessions were organized to develop this idea in mock-ups to visualize the industry platform functionality as shown in **Figure 28**.

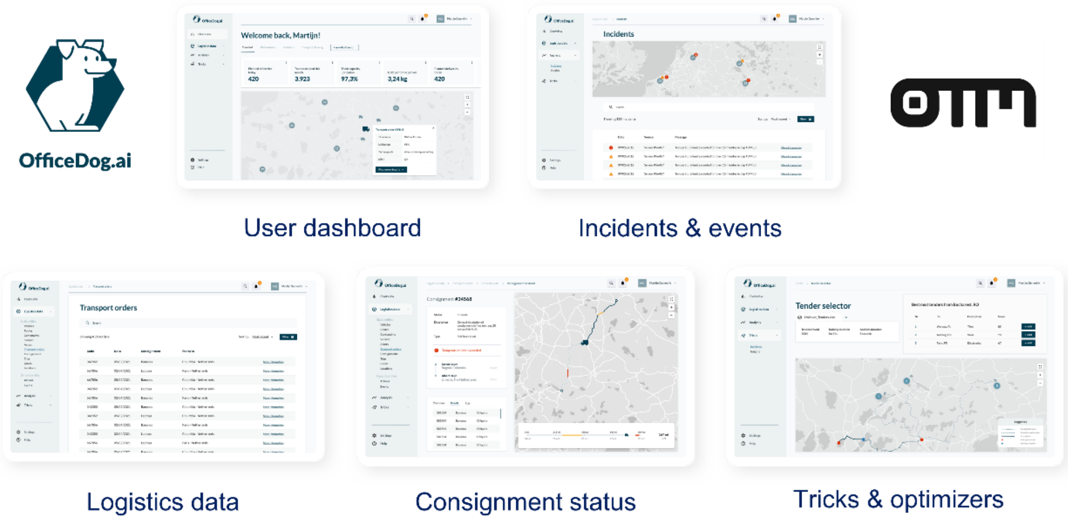


Figure 28: Mock-ups of the industry platform.

The mock-ups are used for stakeholder interaction, development of the GUI, and writing user stories for testing purposes. Detailed versions of the mock-ups are included in **Appendix H**.

6.4.3 Development iterations

The industry platform is developed based on the architecture in **Figure 26** and implemented in three iterations. **Table 10** summarizes the functionalities and features of each iteration.

Iteration	Functionalities		Features
1		1) GUI	- User dashboard - Data collection via manual input - ETL process for batch file import - User management and API Keys
		2) OTM API	- Real-time data exchange using OTM endpoints - Developer documentation
	OTM	3) OTM Database	- Data storage based on OTM compliant database scheme
2		4) Development tool and repository	- Agent repository - Extension to connect with developer tool(s) for agent development, training, and testing - Agent deployment and evaluation
3		5) Infrastructure provisioning	- Provisioning of infrastructure - Automated provisioning of agents - Job orchestration services - Execution and monitoring system

Table 10: Iterations to develop the industry platform and related functionalities.

The results of the three development iterations are documented in **Section 7.3**.

6.4.4 User stories

User stories are defined for the business system stakeholders: the user, system admin, support staff, and system integrator. **Table 11** presents an overview of the user stories.

Iteration	Functionalities		User stories
1		1) GUI	As a user, I want to be able to manually input or alter data, so I can instantly start using the industry platform.
			As a support staff, I can batch upload logistic data using a file import, so I can efficiently input historical data in the industry platform.
			As a system admin, I want to manage users and API keys, so I can control access to the industry platform and data.
		2) OTM API	As a system integrator, I want to have documentation available, so I can develop and test OTM compliant interfaces.
	OTM	3) OTM database	As a user, I want to store my data in a structured format based on OTM, so I can use the data for analytics and optimization.
2		4) Development tool and repository	As a system developer, I want to create re-usable agents, so that applications can be distributed to all users and development efforts will be reduced.
			As a system developer, I want to have developer tool(s) for agent development, training, and testing.
			As a user, I want to have access to the repository, so that I can instantly get started with data analysis and/or optimization.
3		5) Infrastructure provisioning	As a system developer, I want to automate the infrastructure provisioning, so I can easily launch services to train, test and implement agents.
			As a user, I want to automatically deploy agents, without IT knowledge, so I can start using data-driven applications.
			As a system developer, I want to have job orchestration services and monitoring, so I can balance heavy load and idle time and optimize computational resources.

Table 11: Overview of industry platform testing and validation results.

The user story test criteria and industry platform testing results are documented in **Section 7.2**.

6.5 Supporting artefacts

This section presents the supporting artefacts that are developed to complement the industry platform based on organizational dominant BIE.

Subsection 6.5.1 contains an overview of the iterations and related artefacts	**Step 3 of DSRM**
Subsection 6.5.2 presents the IA design canvas and workshop materials	Development
Subsection 6.5.3 contains the implementation guidelines and adoption framework	

6.5.1 Iterations and related artefacts

Based on earlier work, the developed method for RL-driven business process re-engineering from Gemmink (2019) and the process model for realizing value from BI, theory ingrained artefacts are developed to support the processes related to the design, (prototypical) development, test, deployment, adoption, and use of agents based on the concepts of IA. **Table 12** presents an overview of the iterations to develop supporting artefacts to complement the industry platform.

Iteration	**Supporting artefacts**		**Main aim of the artefact**
1		Design canvas	Supporting researchers, practitioners, and end-users to ideate and conceptualize data-driven logistics applications.
		Workshop materials	Supporting trainers and facilitators to organize design canvas workshops.
2		Implementation guidelines	Supporting researchers, practitioners, and end-users during the implementation process of data-driven logistics applications.
		Adoption framework	Measure and monitor adoption, IA effects, and benefits realization during the implementation.

Table 12: Iterations to create supporting artefacts for the industry platform.

Following the organizational dominant BIE, the design canvas, supporting workshop materials, developed implementation guidelines and adoption framework are validated using case study research at Emons. The results are documented in **Section 7.4**.

6.5.2 IA design canvas and workshop materials

Based on earlier work (Piest and Iacob, 2020), the IA design canvas, shown in **Figure 29**, is complemented with workshop materials. The workshop materials, presented in **Section 7.5**, support trainers and facilitators to organize design canvas workshops in-company and for mixed groups.

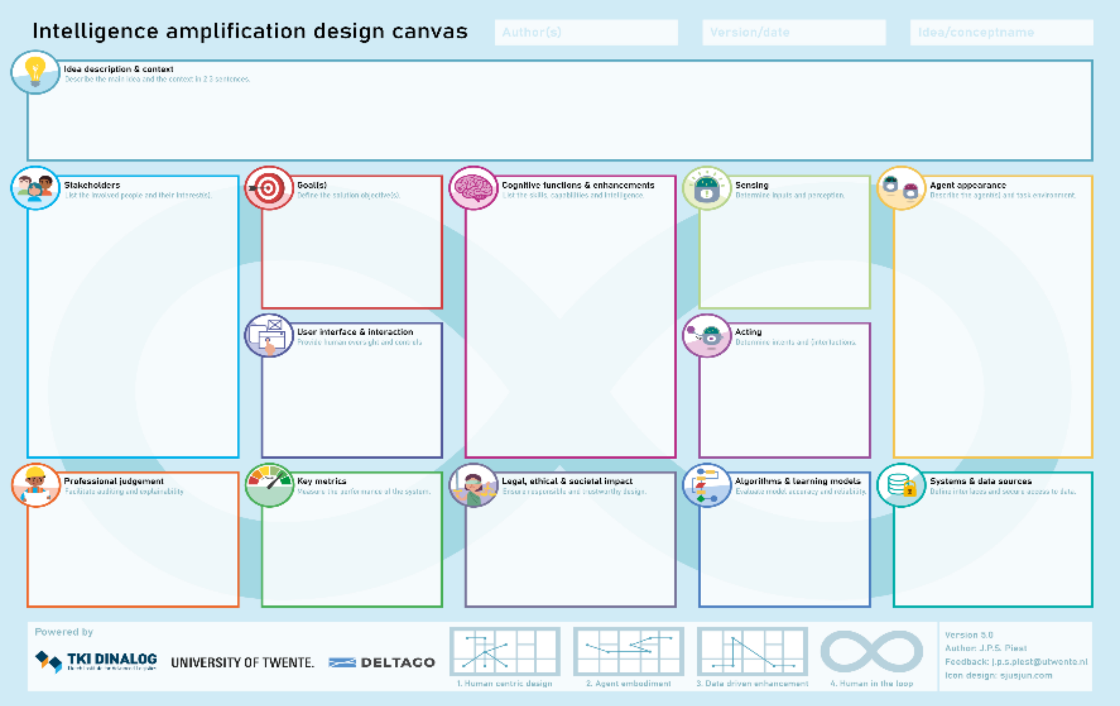


Figure 29: Intelligent amplification design canvas.

The IA design canvas supports researchers, practitioners, and end-users to emphasize, ideate, and conceptualize data-driven logistics applications and incorporate the concepts of IA. The conceptualization layer is to emphasize the ideas and context. This is the starting point for discussion and collaboration. The design canvas incorporates conceptual, foundational, and supporting IA concepts and is built to support four design principles. The first principle emphasizes human centric design to achieve responsible and trustworthy AI. The stakeholders and their goals are identified. The user interface and interaction with AI is explored and connected to cognitive functions from a human centric design perspective. In a wider context the legal, ethical, and societal impact is assessed and judgement for auditing and explainability is incorporated. The second design principle makes the agent embodiment as part of a larger technology concept explicit. Here, the physical and/or virtual appearance is linked to the intelligent agent concept and its environment, sensing, and acting capabilities. Cognitive functions are made explicit from a machine intelligence perspective. The third design principle makes the use of data-driven approaches, algorithms, learning models, and data sources explicit. Key metrics are incorporated to measure the impact and performance of the system and contribute to professional judgement. The fourth design principle is based on the human in the loop concept and is used to assess completeness and consistency of the design.

6.5.3 Implementation guidelines and adoption framework

Based on the method for RL-driven business process re-engineering of Gemmink (2019), shown in **Figure 30**, implementation guidelines are developed.

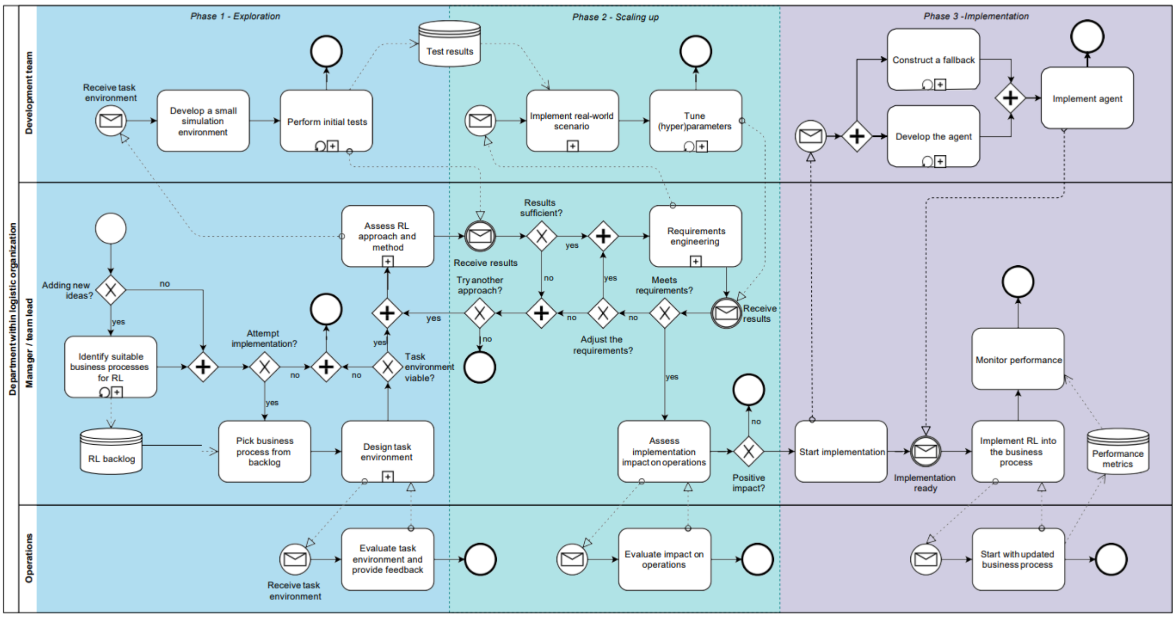


Figure 30: Method for RL-driven business process re-engineering (image: Gemmink, 2019).

A set of 10 implementation guidelines are developed to support the processes:

1) Determine feasibility: the method starts with the identification of suitable business processes and ideation of data-driven logistics applications. This results in a backlog. Prior to selection, the feasibility of algorithms should first be assessed by a subject matter expert in consultation with the stakeholders;

2) Set performance expectations: prior to development, the expectations of involved stakeholders should be made explicit in the form of a project initiation document. This contributes to the evaluation in a later stage;

3) Collect, visualize, and explore the data: map the use of information systems in addition to the identified business process and collect available internal and external data. Visualizing and exploring the data contributes to better understanding of the use case requirements and setting/refining goals and expectations;

4) Create the environment, the model and rewards system: determine the solution space based on the collected data and goals. Start small and design a task environment for validation by stakeholders. Adjust based on feedback and select the models, including the rewards system and performance metrics, for the initial experiment with a subject matter expert. Create a small simulation environment for initial tests;

5) Train and test one or multiple RL algorithms: run the model for initial training and store the results for analysis;

6) Perform initial tests and tune (hyper)parameters: Evaluate the (intermediate) results based on the use case requirements and model performance metrics. Adjust the model configuration, its (hyper)parameters and repeat the previous step until results satisfy the requirements and meet the desired performance. Share the test results with involved stakeholders for validation;
7) Assess the business impact: evaluate the results based on the goals and expectations, set in 2 and 4, and assess the use and impact of the agent. Determine the need and efforts to re-engineer the business process. Develop the agent and prepare the implementation;
8) Construct a fallback: ensure a fallback solution prior the actual implementation and actual use of the RL agent to ensure the continuity of business processes;
9) Monitor the performance of the agent: store performance metrics and periodically assess the use and impact of the RL agent with involved stakeholders;
10) Iterate to improve or adapt the agent: periodically retrain the model to assess improvement potential and update the agent based on user feedback and performance metrics.

Based on the process model for realizing value from BI of Crossland and Smith (2008), illustrative output, metrics, and KPIs are defined to measure and monitor adoption, IA effects, and benefits realization. **Table 13** presents the adoption framework that can be used during the implementation.

Process	Results in	Requires	Output, metrics, KPIs
Initiation	Strategic imperative	Strategic appreciation	C-level commitment
	Opportunities identified	Articulation of needs and requirements	Business case Project charter
	Roadmap established	Prioritizing of needs	Projects in progress Backlog
IT alignment	IT expenditure	Allocation of financial and human resources	€ OPEX € CAPEX # Hours internal # Hours external
IT conversion	IT assets	IT project management	# Agents developed # Agents in use
IT use	IT impact	(In)appropriate use	Score card per agent IA effects, candidates: - User efficiency - Cognitive-task fit - User adoption

			- User satisfaction
Competitiveness building	Competitive position	Business-IT alignment	Score card per process, candidates: - Capacity / output - Lead times - Transaction cost
Benefits realization management	Actual value captured	Measurement and monitoring	Score card for organization, candidates: - Overall effectiveness - Operational efficiency gains - IT costs and savings - Value of benefits - Return on Investment - Payback period

Table 13: Framework to measure and monitor adoption, IA effects, and benefits realization.

6.6 Summary and conclusion

This chapter documented the design and development processes and artefacts following the design methodology from **Chapter 5**. Systems thinking is utilized to conceptualize the industry platform in the context of the logistics industry. The main data sources are identified and explored using an extended version of the nine-window diagram. Lifecycle and time scale thinking are applied to analyse the OTM. The feasibility of using OTM for process mining is evaluated based on earlier work and broader use for analytical purposes is explored. This resulted in a variety of opportunities for data-driven logistics applications. Subsequently, the industry platform architecture is modelled using the ArchiMate language and specification. The layered architecture of the industry platform is presented and decomposed in components and interfaces. Next, a concrete architecture is modelled and presented for the industry platform and the OTM is formalized in an ER diagram. The actual development and implementation of the industry platform is done in three iterations by a research, design, and development team. Mock-ups are created to visualize the industry platform. User stories are created to guide the development process. Extending earlier and related work, an IA design canvas, workshop materials, implementation guidelines, and adoption framework to measure and monitor the implementation are developed to complement the industry platform.

DEMONSTRATION AND VALIDATION

7 Demonstration and validation

This chapter demonstrates the use of the industry platform and contains the results and insights gained from testing, improvement, and validation of the industry platform. **Section 7.1** contains the results of the expert panel consultation. **Section 7.2** illustrates the instantiated industry platform's main functionalities and interfaces in use. **Section 7.3** contains the results of industry platform testing and improvement iterations. **Section 7.4** documents the results from case-based research at Emons to validate the implementation guidelines. **Section 7.5** documents the results of impact development as part of the learning community. **Section 7.6** summarizes and concludes the chapter. This chapter contains parts of earlier work in published articles.[30]

7.1 Expert panel consultation

In line with the **Section 6.2 and 6.3**, an expert panel was composed, as shown in **Table 14**, to verify the ideas and concept of operation from a wider system environment perspective and validate the industry platform architecture and its main functionalities.

Expert	Organization	Background	Experience	Motivation
Senior policy maker	SUTC	Bachelor in Logistics and Economics	15 years in policy making and 20 years in logistics	Responsible for IT development in the industry, in specific standardization (incl. OTM, iSHARE)
Project manager	Evofenedex	Master in Supply Chain Management	3 years at branch organization and 5 years in logistics	Responsible for digital transformation program for shippers and logistics services providers, consults organizations which are potential users
Independent IT expert	Lambooij Logistiek	Bachelor in Logistics Engineering	13 years as independent IT consultant, 6 years at branch organization and 10 years in logistics	Responsible for independent selection and implementation of IT solutions for logistics, experience in OTM implementations, consults organizations which are potential users

Table 14: Composition of the expert panel.

---

[30] **Section 7.1 and 7.4** is related to the research paper (Piest et. al., 2021). **Section 7.2** is added and **Section 7.3** significantly extends earlier work. Parts of **Subsection 7.4.1 and 7.5.1** are incorporated in a conference paper (Piest, Iacob, and Wouterse, 2022).

The expert panel meeting was organized online via Microsoft Teams due to government restrictions to meet in person. All panel members were positive about the industry platform's goals and agreed that the GUI is suitable for SMEs. The Excel importer relates well to current data use and available knowledge in SMEs and is an interesting intermediate solution in between manual data entry and using APIs. The panel raised concerns regarding the current adoption of the OTM in the Dutch logistics industry and capabilities of logistics information systems to connect to APIs. The industry platform is expected to lower barriers to start experimenting with data-driven logistics applications and the proposed collective approach via the learning community is expected to increase adoption by a larger user group. The panel members doubt whether small enterprises are willing to invest time and efforts in such an industry platform. The panel emphasized that most SMEs are not ready for advanced data analytics and require guidance to adopt these applications in their daily operations. Furthermore, the panel was positive about the connection of the OTM and iSHARE as part of the federated data sharing infrastructure but emphasized that the digital transformation will require strategic support and a long-term commitment.

7.2 Development testing and improvement

This section presents the results of development testing per iteration and improvements.

Subsection 7.2.1 presents the test results and findings	**Step 4 and 5 of DSRM**
Subsection 7.2.2 highlights platform improvements as part of ADR iterations	Demonstration
Subsection 7.2.3 presents the results from integration testing	Validation

7.2.1 Test results and findings

In line with **Section 6.4** and the user stories in **Subsection 6.4.4**, the results of each development iteration are tested. **Table 15** presents an overview of the development test results and findings.

Iteration	Functionalities	User stories	Test criteria	Results and findings
1	1) GUI	As a user, I want to be able to manually input or alter data, so I can instantly start using the industry platform.	Each OTM entity has CRUD options made available via a web-based form.	Web-based form available for each OTM entity. The input is in REST JSON and too technical.
		As a support staff, I can batch upload logistic data using a file import, so I can efficiently input historical	Each OTM entity can be imported in batch using an import template.	Web-based import option based on Excel template. Each OTM entity can be imported in batch.

		data in the industry platform.		The associations are difficult to configure. Validation and error messages can be added.
		As a system admin, I want to manage users and API keys, so I can control access to the industry platform and data.	Endpoints are only accessible via a valid API key. Entity access is governed via CRUD access controls.	Basic CRUD actions are operational and tested via Postman. API endpoints are not available without valid key.
	2) OTM API	As a system integrator, I want to have documentation available, so I can develop and test OTM compliant interfaces.	Each endpoint is documented in the API documentation page and contains description of the operations and examples of request and response messages.	The API documentation contains all OTM entities and related operations. Most of the provided example requests can be re-used for testing.
	3) OTM database OTM	As a user, I want to store my data in a structured format based on OTM, so I can use the data for analytics and optimization.	The ER is compliant to OTM and is accessible to users in the industry platform.	Users can access and alter the database data via the industry platform. There is currently no direct access to the database.
2	4) Development tool and	As a system developer, I want to create re-usable agents, so that applications can be distributed to all	Re-usable agents can be created, stored, and duplicated.	System developers can create new agents based on available data in the industry platform.

	repository	users and development efforts will be reduced.		
		As a system developer, I want to have developer tool(s) for agent development, training, and testing.	Industry platform extension to developer environment.	The industry platform extension is realized for system developers, e.g. a notebook.
		As a user, I want to have access to the repository, so that SMEs can instantly get started with data analysis and/or optimization.	Re-usable agents can be made available to users in SMEs.	The repository is available to users, however not yet automated with infrastructure provisioning, system developers can enable agents for SMEs.
3	5) Infrastructure provisioning	As a system developer, I want to automate the infrastructure provisioning, so I can easily launch services to train, test and implement agents.	Automated provisioning via scripts and templates.	Kubernetes cluster is available, and jobs can be executed or scheduled via command line interfaces.
		As a user, I want to automatically deploy agents, without IT knowledge, so I can start using data-driven applications.	Automated provisioning via web-based forms by end-users.	The functionality is realized in the front-end to train and deploy agent templates, however, not released to end-users for cost controlling purposes.
		As a system developer, I want to have job orchestration services and monitoring,	Automated job execution and orchestration on top of	Kubernetes is supporting this functionality, however this process is not yet

		so I can balance heavy load and idle time and optimize computational resources.	provisioning of infrastructure.	automated, system developers can monitor the job execution in an admin portal.

Table 15: Overview of development test results and findings.

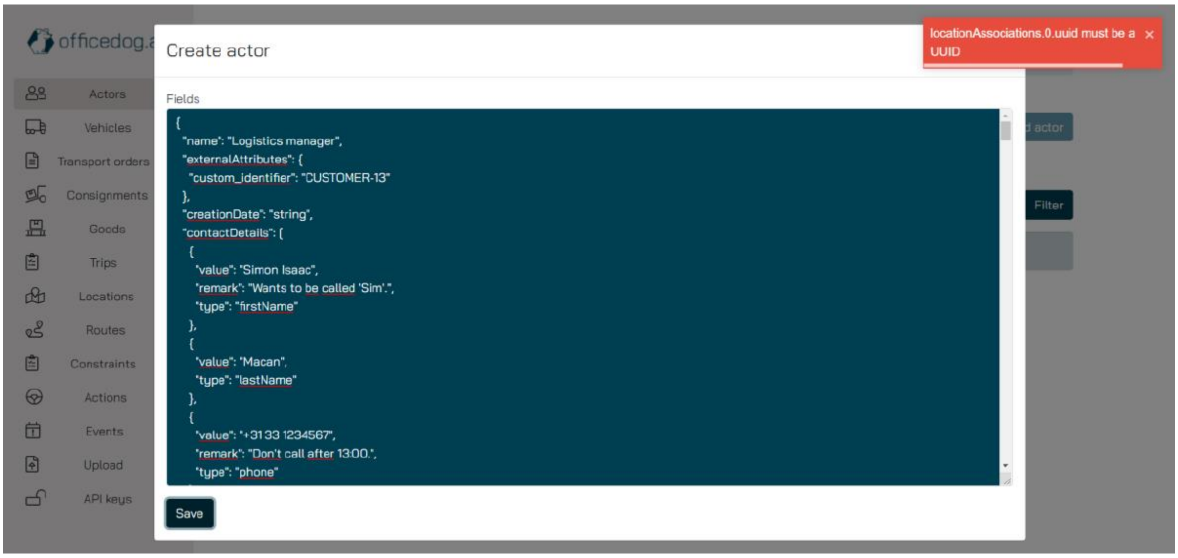
As mentioned in **Subsection 3.2.4** regarding the programme of requirements, the focus of the development was on the realization of the core industry platform functionalities and interfaces. In the three iterations, the 5 main components are realized and most of the user story test criteria are satisfied. The integration with external systems can take place based on the OTM API or via ETL processes using the file import in the GUI. Based on the design decisions in **Section 6.1**, the development team is capable to develop agents and use the developer tools and repository.

7.2.2 Industry platform improvement cycles

Based on the test results and findings, several improvements are identified, and some are incorporated in the industry platform following IT dominant BIE.

7.2.2.1 First iteration

The results of the first development iteration were tested by the researcher and the results are shared with the development team for industry platform improvements. The main improvement that was identified were the input forms in the GUI to create or update OTM entities. **Figure 31** shows the initial GUI. In the second development iteration, forms for end-users are incorporated.



locationAssociations.0.uuid must be a UUID

```
{
 "name": "Logistics manager",
 "externalAttributes": {
  "custom_identifier": "CUSTOMER-13"
 },
 "creationDate": "string",
 "contactDetails": [
  {
   "value": "Simon Isaac",
   "remark": "Wants to be called 'Sim'.",
   "type": "firstName"
  },
  {
   "value": "Macan",
   "type": "lastName"
  },
  {
   "value": "+3133 1234567",
   "remark": "Don't call after 13:00.",
   "type": "phone"
```

Figure 31: Screenshot of GUI after the first development iteration.

Some other improvements were identified and discussed. In the first version of the industry platform, the homepage was blank. In the second development iteration, a user dashboard will be incorporated to show KPIs and charts. During the testing sessions with the Excel import file, it became clear that it is difficult to make associations. It is possible to connect entities, but it requires quite some effort and is error prone. This feature will be tested with end-users and the development team will investigate the efforts to develop functionality. Another improvement is to add more detailed validation and error messages in the file import screen. This feature is put on the backlog.

7.2.2.2 Second iteration

After finishing the second development iteration, the industry platform is tested by the researcher and in a separate session with potential end-users at Emons as illustrated by **Figure 32**.

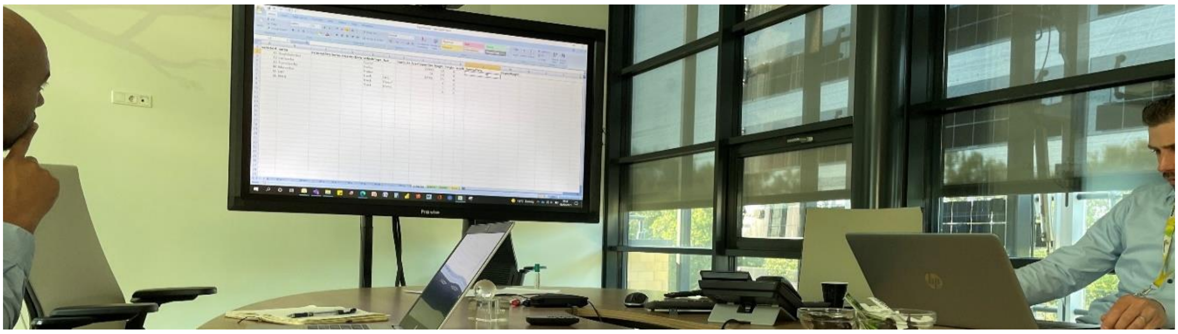


Figure 32: Industry platform testing session at Emons.

The involved end-users provided valuable feedback. Both experienced the GUI to be intuitive and liked the file import functionality. During the session, sample data was used to explore the OTM. The sample file is useful. However, conventions can be made more explicit. Based on the feedback, the API access functionality is considered rudimentary. Advanced profiling should be incorporated. The improved input forms were perceived easy to use. The main learning from testing with end-users is that the dynamic translation of form input into REST JSON is very useful to learn about the OTM and its entities, properties, and associations. Furthermore, two ideas for improvement were discussed. The first improvement is to create an import wizard to guide the process of importing data, e.g., first import master data, then import historical transactional data, enrich with event data. The second improvement is related to general use of OTM. The OTM is flexible and does not prescribe intended use in detail. This can be made explicit in sequence diagrams and choreographies.

7.2.2.3 Third iteration

After finishing the third development iteration, the industry platform is tested by the development team together with potential end-users at Emons as illustrated by **Figure 33**.

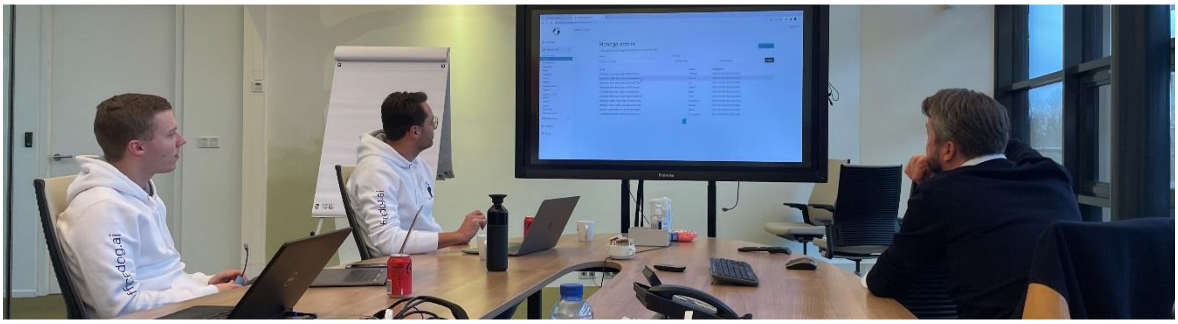


Figure 33: Industry platform validation session at Emons.

The development team tested the use of the industry platform to develop a new agent using real-life data set at Emons. The results and findings are discussed in detail in **Subsections 7.4.4. and 7.4.5**. The main learning is that embodiment of visualizations in the GUI contributes to better and faster understanding of involved stakeholders. Future development work will focus on developing functionality for system developers, system administrators, and end-users to facilitate co-development and self-service.

7.2.3 Integration testing during OTM workshop

On the 26th of January 2022, SUTC organized an online workshop regarding data exchange based on the OTM. This hands-on workshop provided an opportunity to test the industry platform's OTM APIs. An illustrative Transport Order was supplied in JSON by the organizers. The input and test results are included in **Appendix I**. Based on the first test request, the industry platform returned a 400-response message with error details. Based on the analysis, the main issue was caused by one field containing a mobile phone number that was added in a new version of OTM. The other issues were resolved by adding an entity type to the request. The second integration test successfully processed the Transport Order in the industry platform using OTM APIs.

7.3 Industry platform instantiation

In line with **Section 6.3 and 6.4**, this section describes the main functionalities and related artefacts of the instantiated industry platform with illustrative screenshots.

Subsection 7.3.1 presents the developed GUI
Subsection 7.3.2 documents the developed OTM API endpoints
Subsection 7.3.3 presents the developed OTM database
Subsection 7.3.4 presents the repository and use of development tools
Subsection 7.3.5 highlights the established infrastructure and provisioning tools

Step 4 of DSRM
Demonstration

7.3.1 GUI

A web-based GUI is created and currently contains 5 modules: overview, logistics data, integration, analysis (in development), and tricks. **Figure 34** shows the current version of the GUI. The users, system support staff, and the system admins are granted access to the system based on roles and basic authorizations (e.g., Create, Read, Update, and Delete (CRUD)) to manage their data based on the OTM. In the Overview module, the dashboard is shown. The dashboard is designed to provide instant insight into the current performance and highlights selected statistics, KPIs, and visualizations.

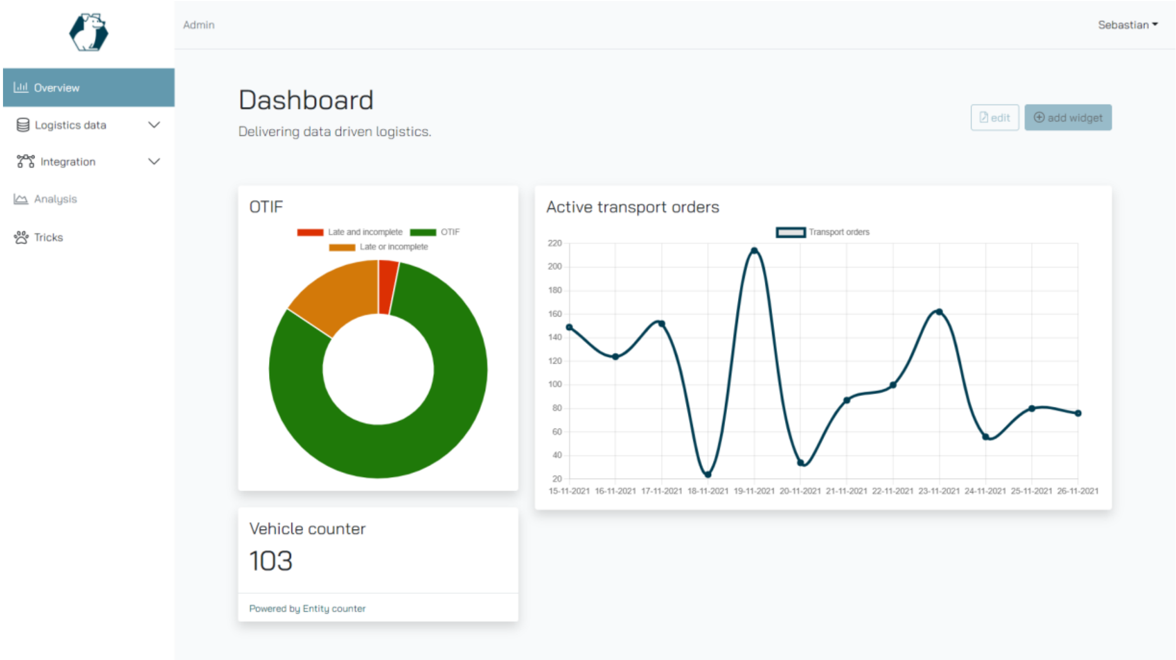
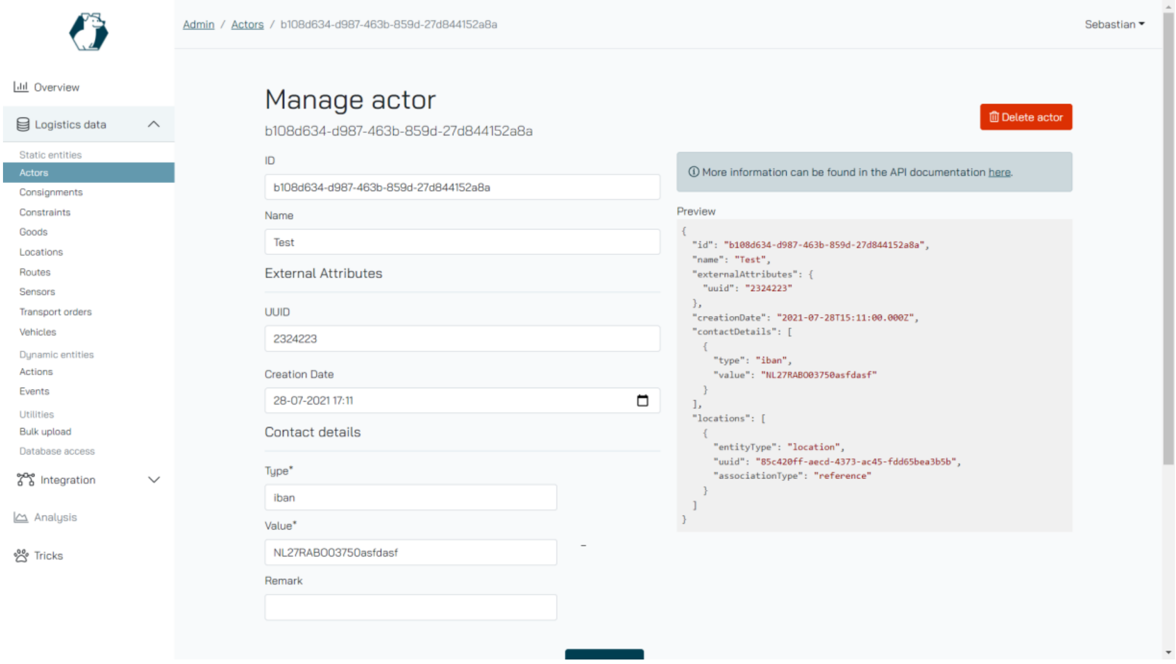


Figure 34: User dashboard in the industry platform.

In the Logistics Data module, the users can access, manually input, alter, and manage their data. Each screen is connected to the OTM database and provides a human readable input form and OTM representation as shown in **Figure 35**. This way, when manually inputting data, the user sees how the input is converted into OTM.



ID: b108d634-d987-463b-859d-27d844152a8a

Name: Test

External Attributes

UUID: 2324223

Creation Date: 28-07-2021 17:11

Contact details

Type*: iban

Value*: NL27RABO03750asfdasf

Remark:

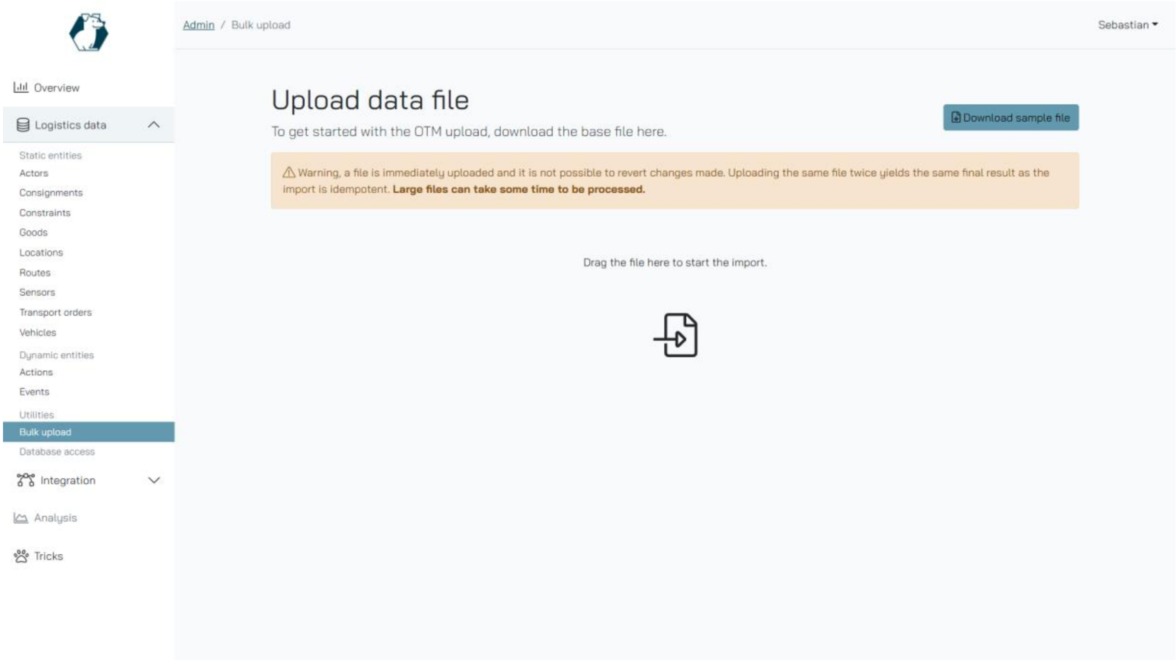
More information can be found in the API documentation here.

Preview

```
{
  "id": "b108d634-d987-463b-859d-27d844152a8a",
  "name": "Test",
  "externalAttributes": {
    "uuid": "2324223"
  },
  "creationDate": "2021-07-28T15:11:00.000Z",
  "contactDetails": [
    {
      "type": "iban",
      "value": "NL27RABO03750asfdasf"
    }
  ],
  "locations": [
    {
      "entityType": "location",
      "uuid": "85c420ff-aecd-4373-ac45-fdd65bea3b5b",
      "associationType": "reference"
    }
  ]
}
```

Figure 35: Manual input and altering of logistics data.

In the utilities screen, system admins can batch import data using the Excel importer. **Figure 36** shows the screen that system administrators use to upload data files.



Upload data file

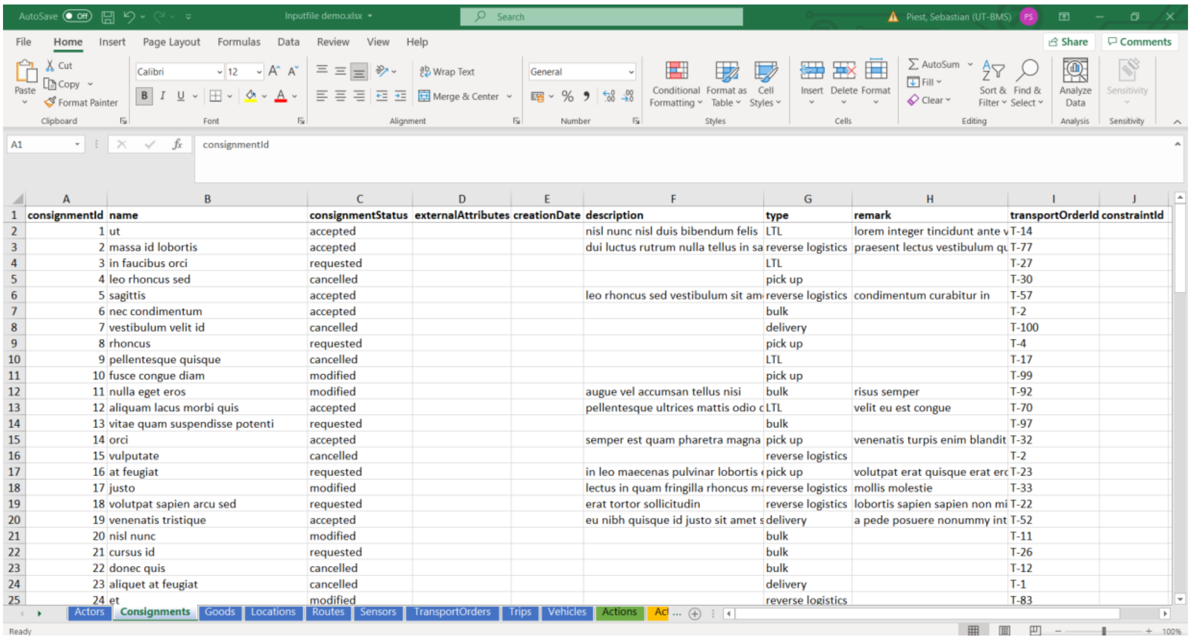
To get started with the OTM upload, download the base file here.

Warning, a file is immediately uploaded and it is not possible to revert changes made. Uploading the same file twice yields the same final result as the import is idempotent. **Large files can take some time to be processed.**

Drag the file here to start the import.

Figure 36: Bulk upload feature.

Currently, database access is possible via a direct connection to connect existing reporting and BI tools to the industry platform. In a later stage, database access will be enabled via the GUI. In order to facilitate ETL processes, system administrators can download a sample file. The sample file, as shown in **Figure 37**, is based on the OTM. Each tab contains an entity. System administrators can manually upload logistics data per entity or in batch upload all data at once.

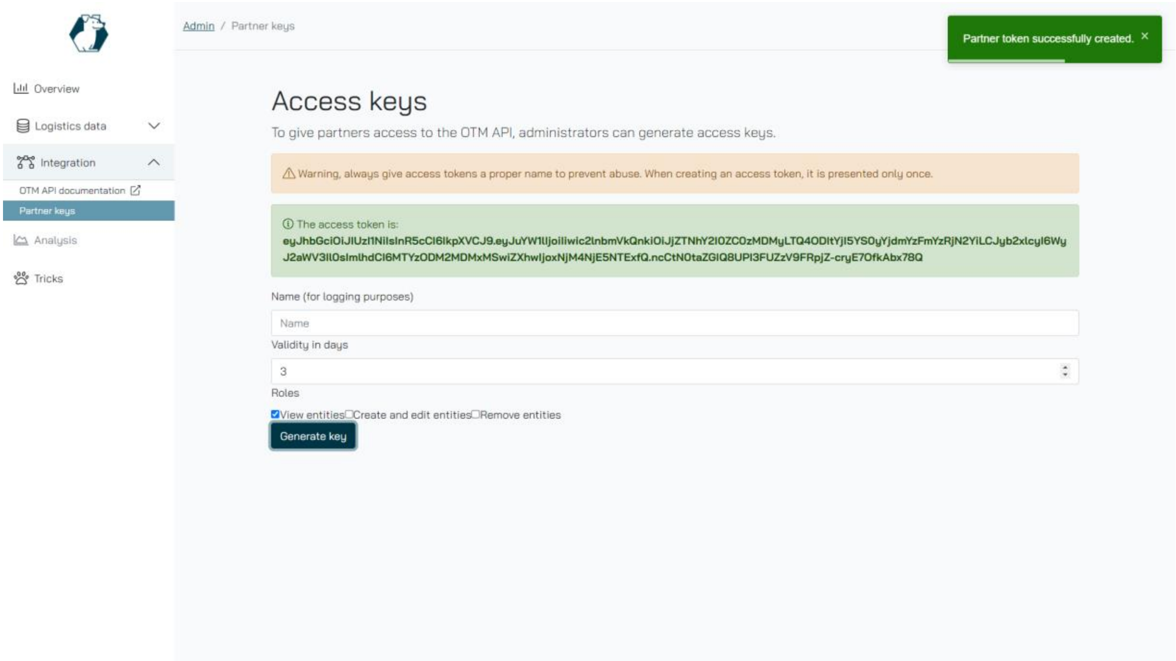


consignmentId

consignmentId	name	consignmentStatus	externalAttributes	creationDate	description	type	remark	transportOrderId	constraintId
1	ut	accepted			nisl nunc nisl duis bibendum felis	LTL	lorem integer tincidunt ante v	T-14	
2	massa id lobortis	accepted			dui luctus rutrum nulla tellus in sa	reverse logistics	praesent lectus vestibulum qu	T-77	
3	in faucibus orci	requested				LTL		T-27	
4	leo rhoncus sed	cancelled				pick up		T-30	
5	sagittis	accepted			leo rhoncus sed vestibulum sit am	reverse logistics	condimentum curabitur in	T-57	
6	nec condimentum	accepted				bulk		T-2	
7	vestibulum velit id	cancelled				delivery		T-100	
8	rhoncus	requested				pick up		T-4	
9	pellentesque quisque	cancelled				LTL		T-17	
10	fusce congue diam	modified				pick up		T-99	
11	nulla eget eros	modified			augue vel accumsan tellus nisi	bulk	risus semper	T-92	
12	aliquam lacus morbi quis	accepted			pellentesque ultrices mattis odio c	LTL	velit eu est congue	T-70	
13	vitae quam suspendisse potenti	requested				bulk		T-97	
14	orci	accepted			semper est quam pharetra magna	pick up	venenatis turpis enim blandit	T-32	
15	vulputate	cancelled				reverse logistics		T-2	
16	at feugiat	requested			in leo maecenas pulvinar lobortis (	pick up	volutpat erat quisque erat erc	T-23	
17	justo	modified			lectus in quam fringilla rhoncus ma	reverse logistics	mollis molestie	T-33	
18	volutpat sapien arcu sed	requested			erat tortor sollicitudin	reverse logistics	lobortis sapien sapien non mi	T-22	
19	venenatis tristique	accepted			eu nibh quisque id justo sit amet s	delivery	a pede posuere nonummy int	T-52	
20	nisl nunc	modified				bulk		T-11	
21	cursus id	requested				bulk		T-26	
22	donec quis	cancelled				bulk		T-12	
23	aliquet at feugiat	cancelled				delivery		T-1	
24	et	modified				reverse logistics		T-83	

Figure 37: Excel import template based on the OTM.

In the Integration module, system administrators can create API users for external partners. Basic authorizations are implemented to determine access rights. **Figure 38** shows the screen that system administrators use to create API keys.



Access keys

To give partners access to the OTM API, administrators can generate access keys.

⚠ Warning, always give access tokens a proper name to prevent abuse. When creating an access token, it is presented only once.

ⓘ The access token is:
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJuYW1lIjoiIiwic2lnbmVkQnkiOiJjZTNhY2I0ZC0zMDMyLTQ4ODItYjI5YS0yYjdmYzFmYzRjN2YiLCJyb2xlcyI6WyJ2aWV3Il0sImlhdCI6MTYzODM2MDMxMSwiZXhwIjoxNjM4NjE5NTExfQ.ncCtN0taZGIQ8UPI3FUZzV9FRpjZ-cryE70fkAbx78Q

Name (for logging purposes)

Name

Validity in days

3

Roles

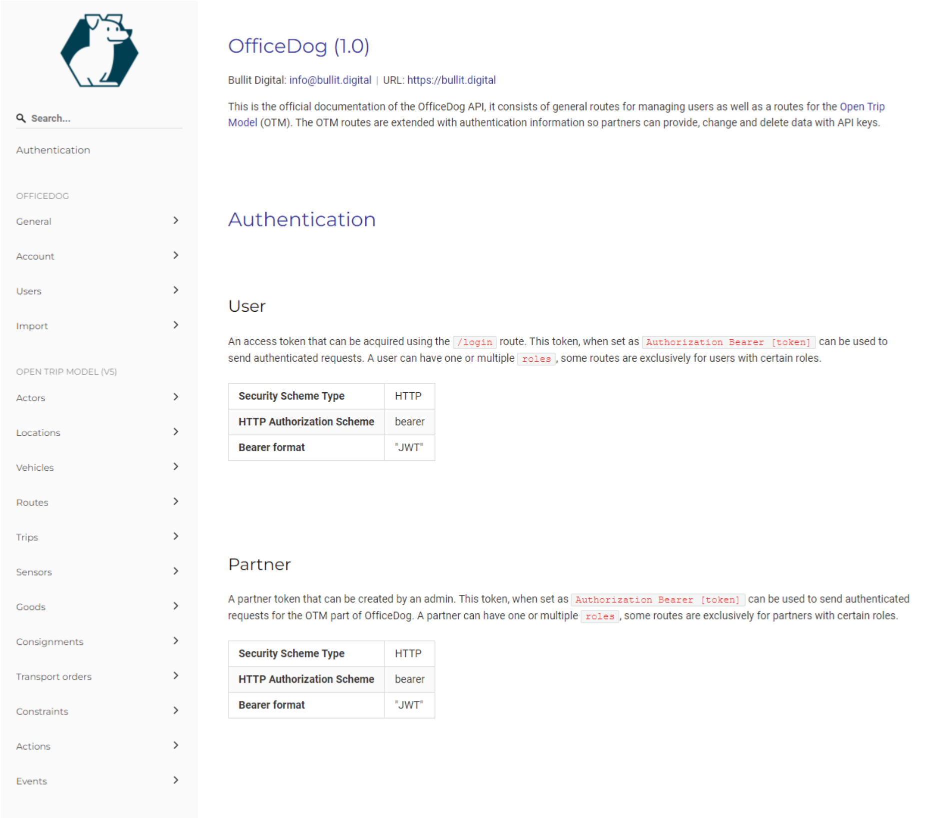
☑ View entities ☐ Create and edit entities ☐ Remove entities

Figure 38: Screen to create API keys for external access.

The implementation is limited to basic CRUD actions. In future versions, differentiation of CRUD actions is foreseen for individual entities and in a later stage iSHARE authorizations and policies.

7.3.2 OTM API

Based on version 5 of OTM, all available operations are instantiated in API endpoints. System integrators are provided API documentation via a developer website as shown in **Figure 39**.



OfficeDog (1.0)

Bullit Digital: info@bullit.digital | URL: https://bullit.digital

This is the official documentation of the OfficeDog API, it consists of general routes for managing users as well as a routes for the Open Trip Model (OTM). The OTM routes are extended with authentication information so partners can provide, change and delete data with API keys.

Authentication

User

An access token that can be acquired using the `/login` route. This token, when set as `Authorization Bearer [token]` can be used to send authenticated requests. A user can have one or multiple `roles`, some routes are exclusively for users with certain roles.

Security Scheme Type	HTTP
HTTP Authorization Scheme	bearer
Bearer format	"JWT"

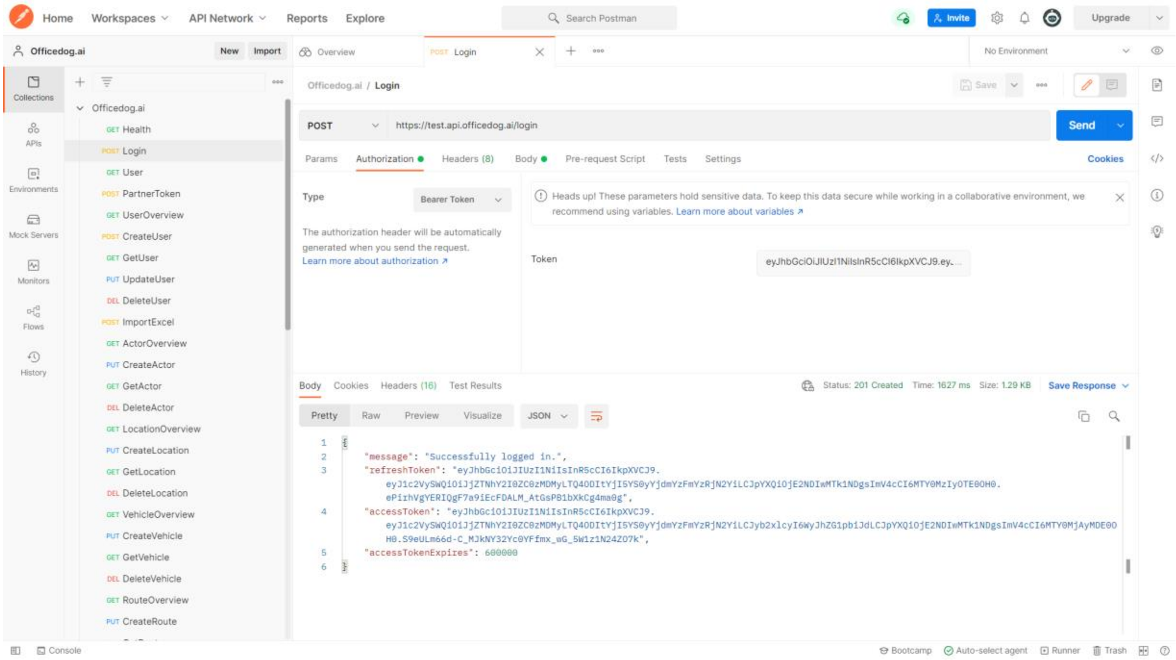
Partner

A partner token that can be created by an admin. This token, when set as `Authorization Bearer [token]` can be used to send authenticated requests for the OTM part of OfficeDog. A partner can have one or multiple `roles`, some routes are exclusively for partners with certain roles.

Security Scheme Type	HTTP
HTTP Authorization Scheme	bearer
Bearer format	"JWT"

Figure 39: API documentation website for developers and system integrators.

The API documentation provides users and partners instructions regarding authentication. Both users and partners can obtain a token using their user account. **Figure 40** shows how developers and system integrators can access and test endpoints in Postman[31].



POST https://test.api.officedog.ai/login

Type: Bearer Token

The authorization header will be automatically generated when you send the request. Learn more about authorization ↗

Heads up! These parameters hold sensitive data. To keep this data secure while working in a collaborative environment, we recommend using variables. Learn more about variables ↗

Token: eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.ey...

Status: 201 Created Time: 1627 ms Size: 1.29 KB

```
{
    "message": "Successfully logged in.",
    "refreshToken": "eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.
        eyJ1c2VySWQiOiJjZTNhY2I0ZC0zMDMyLTQ4ODItYjI5YS0yYjdmYzFmYzRjN2YiLCJpYXQiOjE2NDIwMTk1NDgsImV4cCI6MTY0MzIyOTE0OH0.
        ePirhVgYERIQgF7a9iEcFDALM_AtGsPB1bXkCg4ma0g",
    "accessToken": "eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.
        eyJ1c2VySWQiOiJjZTNhY2I0ZC0zMDMyLTQ4ODItYjI5YS0yYjdmYzFmYzRjN2YiLCJyb2xlcyI6WyJhZG1pbiJdLCJpYXQiOjE2NDIwMTk1NDgsImV4cCI6MTY0MjAyMDE0O
        H0.S9eULm66d-C_MJkNY32Yc0YFfmx_wG_5W1z1N24Z07k",
    "accessTokenExpires": 600000
}
```

Figure 40: API endpoint testing in Postman.

Next, the token is used to access platform services and published endpoints based on OTM. **Table 16** presents an overview of general services and APIs that are made available via APIs.

Category	Service	URL	Request	Response
General	Health check	https://test.api.officedog.ai/health	GET	200 The Health Check is successful 503 The Health Check is not successful
Account	Log in	https://test.api.officedog.ai/login	POST	200 Logged in successfully 400 Bad Request 401 Unauthorized 403 Forbidden 422 Unprocessable Entity
	Refresh token	https://test.api.officedog.ai/refresh	POST	
	Generate partner token	https://test.api.officedog.ai/partners/token	POST	200 Partner API token successfully generated. 401 Unauthorized 403 Forbidden
	Get user	https://test.api.officedog.ai/user	GET	200 User details retrieved successfully

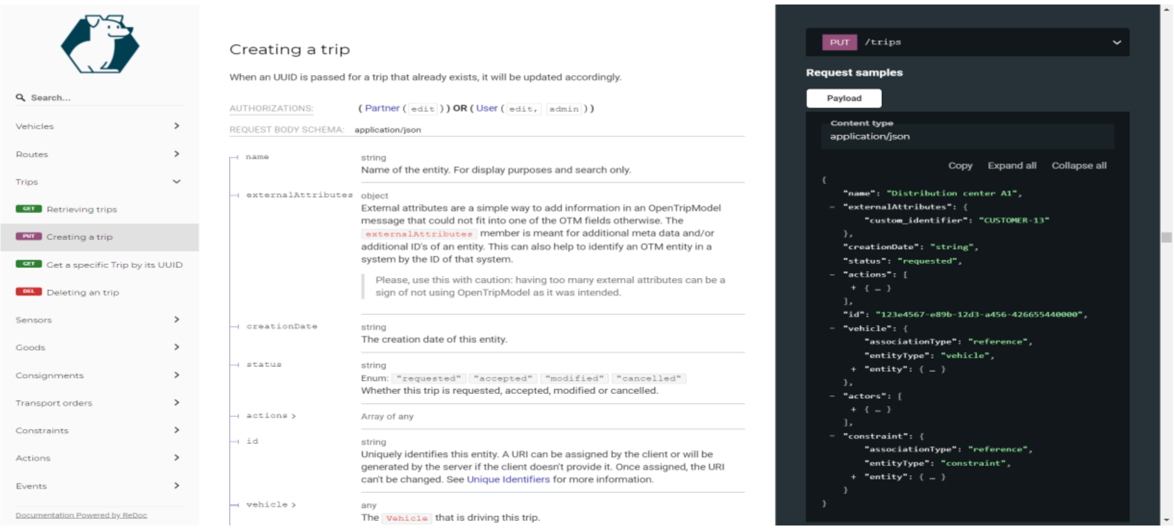
---

[31] https://www.postman.com/

				401 Unauthorized 403 Forbidden 404 User not found
Users	Creating a user	https://test.api.office-dog.ai/users	POST	201 User created successfully 400 Bad Request 401 Unauthorized 403 Forbidden 422 Unprocessable Entity
	Retrieving a user	https://test.api.office-dog.ai/users/{userId}	GET	200 User retrieved successfully 401 Unauthorized 403 Forbidden 404 No users found
	Updating a user	https://test.api.office-dog.ai/users/{userId}	PUT	200 User updated successfully 401 Unauthorized 403 Forbidden 404 User not found
	Deleting a user	https://test.api.office-dog.ai/users/{userId}	DELETE	200 User deleted successfully 401 Unauthorized 403 Forbidden 404 User not found
	Retrieving users	https://test.api.office-dog.ai/users	GET	200 User retrieved successfully 401 Unauthorized 403 Forbidden 404 No users found
Import	Import entities	https://test.api.office-dog.ai/import/excel	POST	200 File successfully uploaded 400 Bad Request 401 Unauthorized 403 Forbidden

Table 16: Overview of industry platform services and APIs.

The authentication service is realized, but not yet connected to an iSHARE register. On a technical level, the OAuth 2.0 protocol meets the prerequisites to integrate with iSHARE in a later stage. Based on the OTM specification, APIs are realized to exchange logistics data. **Figure 41** illustrates published endpoint for creating a trip.



Creating a trip

When an UUID is passed for a trip that already exists, it will be updated accordingly.

AUTHORIZATIONS: (Partner (`edit`)) OR (User (`edit,` `admin`))

REQUEST BODY SCHEMA: application/json

`name`	string Name of the entity. For display purposes and search only.
`externalAttributes`	object External attributes are a simple way to add information in an OpenTripModel message that could not fit into one of the OTM fields otherwise. The `externalAttributes` member is meant for additional meta data and/or additional ID's of an entity. This can also help to identify an OTM entity in a system by the ID of that system. Please, use this with caution: having too many external attributes can be a sign of not using OpenTripModel as it was intended.
`creationDate`	string The creation date of this entity.
`status`	string Enum: `"requested"` `"accepted"` `"modified"` `"cancelled"` Whether this trip is requested, accepted, modified or cancelled.
`actions >`	Array of any
`id`	string Uniquely identifies this entity. A URI can be assigned by the client or will be generated by the server if the client doesn't provide it. Once assigned, the URI can't be changed. See Unique Identifiers for more information.
`vehicle >`	any The `Vehicle` that is driving this trip.

Content type
application/json

```
{
    "name": "Distribution center A1",
  - "externalAttributes": {
        "custom_identifier": "CUSTOMER-13"
    },
    "creationDate": "string",
    "status": "requested",
  - "actions": [
     + { … }
    ],
    "id": "123e4567-e89b-12d3-a456-426655440000",
  - "vehicle": {
        "associationType": "reference",
        "entityType": "vehicle",
     +  "entity": { … }
    },
  - "actors": [
     + { … }
    ],
  - "constraint": {
        "associationType": "reference",
        "entityType": "constraint",
     +  "entity": { … }
    }
}
```

Figure 41: Screenshot illustrating OTM API implementation.

Documentation for this endpoint is available at https://test.api.officedog.ai/docs#tag/Trips.

7.3.3 OTM Database

The designed ER diagram, shown earlier in **Figure 27**, is instantiated and serves as the basis for storing data in a structured and standardized format. The database is instantiated using PostgreSQL as illustrated in **Figure 42**.

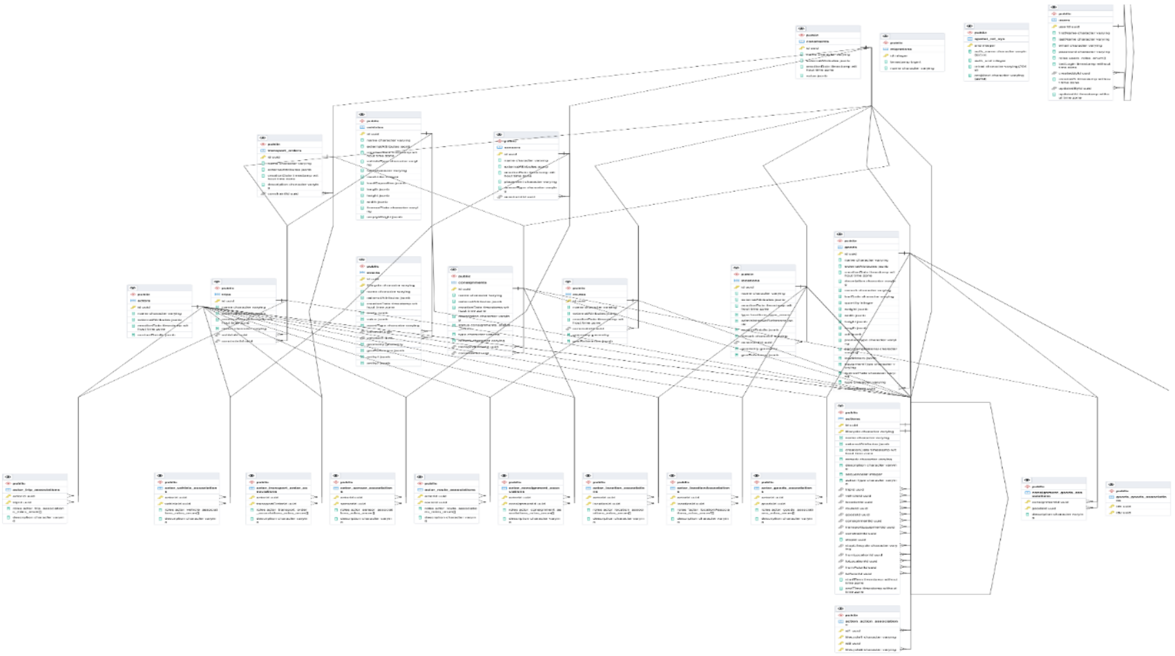
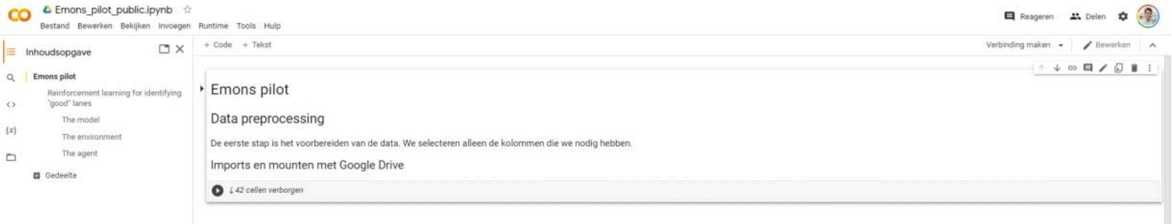


Figure 42: Instantiated ER diagram based on OTM in PostgreSQL (for illustration purposes).

Separate database tables are created for the static entities (e.g., actor, location, vehicle, transport order, consignment, trip, goods, sensor, route, constraint), dynamic entities (e.g., events, actions), and their associations. As mentioned earlier, all OTM entities are also accessible via the GUI. Each SME has its own OTM compliant database.

7.3.4 Repository and development tool

Based on the related work of Gemmink (2019), experience of the development team, and design decisions in **Section 6.1**, the development work is done in Python. Building on previous experience, the use Google Colab[32] is continued to develop re-usable models as shown in **Figure 43**.



Emons pilot

Data preprocessing

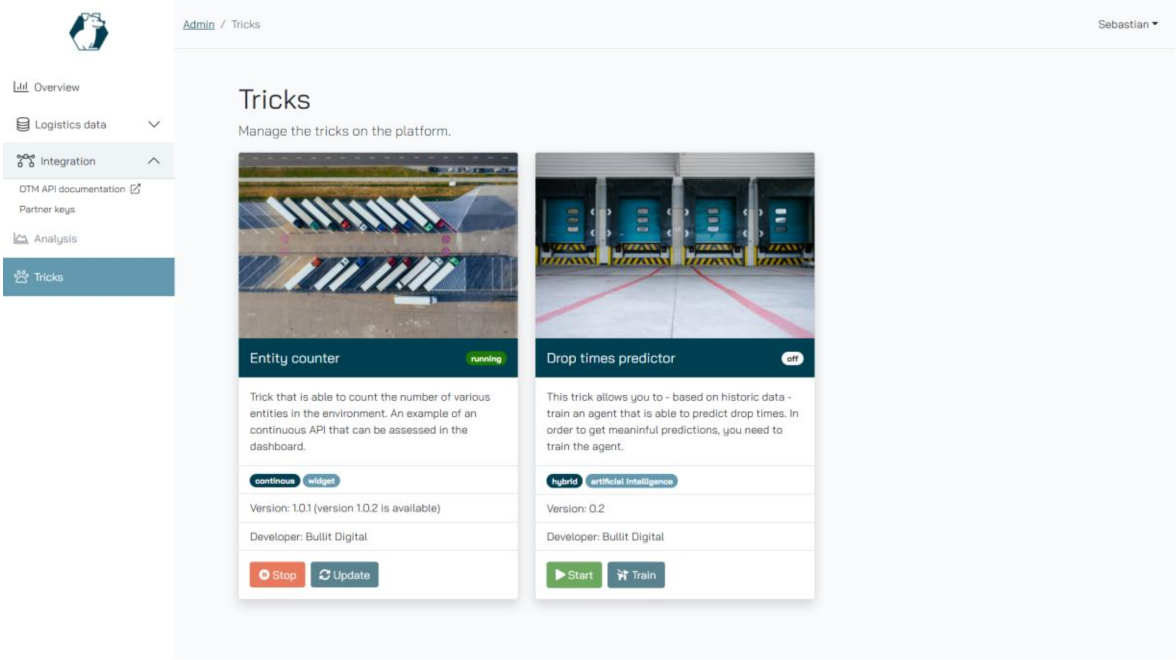
De eerste stap is het voorbereiden van de data. We selecteren alleen de kolommen die we nodig hebben.

Imports en mounten met Google Drive

↓ 42 cellen verborgen

Figure 43: Using Google Colab for development and (local) testing of models.

Notebooks also allow rapid prototyping, (local) testing, and provisioning of computational power to run experiments with large datasets. Additionally, the Google AI platform is suitable for incorporating a broader range of data analytics techniques, visualizations, ML algorithms, and OR approaches. Additionally, notebooks can be split up into different steps and incorporate documentation to create a step-by-step explanation for users and developers. The envisioned repository contains a collection of re-usable agents. **Figure 44** shows how the developed models and templates are presented to users in the Tricks module.



Trick that is able to count the number of various entities in the environment. An example of an continuous API that can be assessed in the dashboard.

Version: 1.0.1 (version 1.0.2 is available)

Developer: Bullit Digital

This trick allows you to - based on historic data - train an agent that is able to predict drop times. In order to get meaninful predictions, you need to train the agent.

Version: 0.2

Developer: Bullit Digital

Figure 44: Repository of re-usable data-driven applications (tricks).

Currently, a re-usable entity counter and a drop times predictor is published. The entity counter contains a counter function that can be connected to each OTM entity. This relatively simple function can instantly be re-used by all users. The drop times predictor is based on supervised ML and

---

[32] https://colab.research.google.com/

is able to predict drop times. In order to use this trick, users need to train the agent. Additional tricks will be added to the industry platform in future development iterations.

7.3.5 Infrastructure provisioning

In order to orchestrate and automate the provisioning of computation power, a Kubernetes cluster is created. Kubernetes is a highly scalable open-source system for deployment automation and development of containerized applications. Additionally, Kubernetes offers several monitoring and management tools as shown in **Figure 45 and 46**.

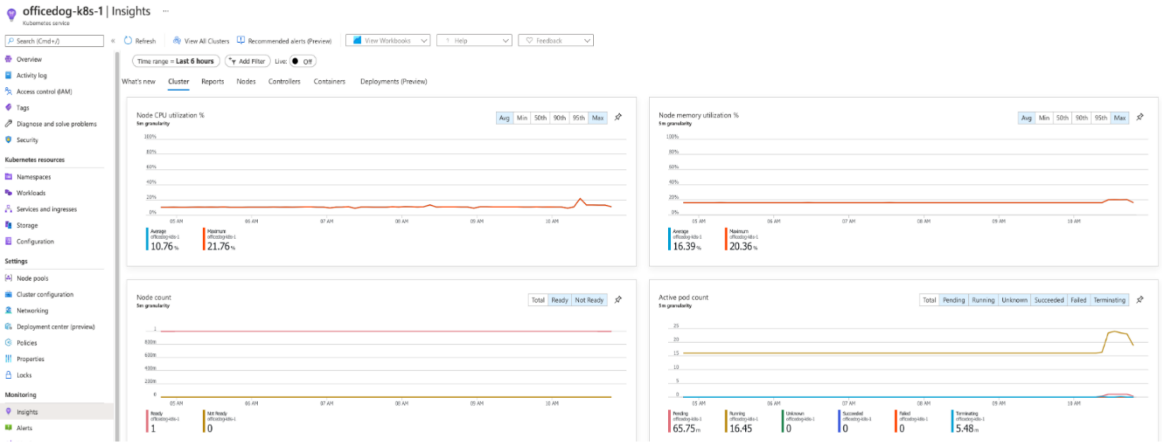
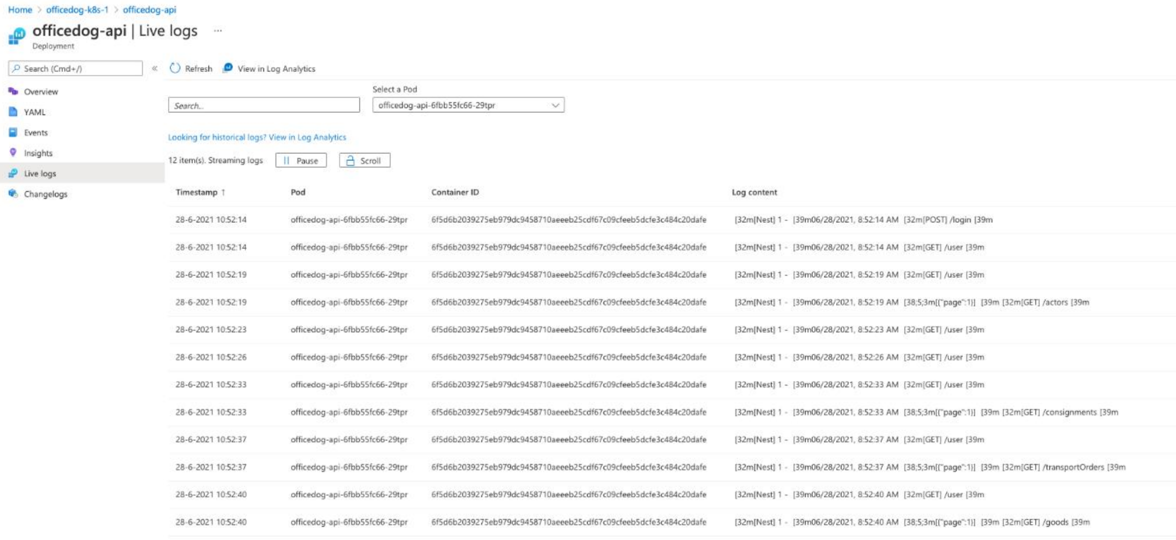


Figure 45: Kubernetes monitoring of the cluster.



Timestamp ↑	Pod	Container ID	Log content
28-6-2021 10:52:14	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:14 AM [32m[POST] /login [39m
28-6-2021 10:52:14	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:14 AM [32m[GET] /user [39m
28-6-2021 10:52:19	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:19 AM [32m[GET] /user [39m
28-6-2021 10:52:19	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:19 AM [38;5;3m[{"page":1}] [39m [32m[GET] /actors [39m
28-6-2021 10:52:23	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:23 AM [32m[GET] /user [39m
28-6-2021 10:52:26	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:26 AM [32m[GET] /user [39m
28-6-2021 10:52:33	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:33 AM [32m[GET] /user [39m
28-6-2021 10:52:33	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:33 AM [38;5;3m[{"page":1}] [39m [32m[GET] /consignments [39m
28-6-2021 10:52:37	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:37 AM [32m[GET] /user [39m
28-6-2021 10:52:37	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:37 AM [38;5;3m[{"page":1}] [39m [32m[GET] /transportOrders [39m
28-6-2021 10:52:40	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:40 AM [32m[GET] /user [39m
28-6-2021 10:52:40	officedog-api-6fbb55fc66-29tpr	6f5d6b2039275eb979dc9458710aeeeb25cdf67c09cfeeb5dcfe3c484c20dafe	[32m[Nest] 1 - [39m06/28/2021, 8:52:40 AM [38;5;3m[{"page":1}] [39m [32m[GET] /goods [39m

Figure 46: Live logs in Kubernetes for API monitoring.

These monitoring and management statistics can be made available to system administrators in a later stage. As introduced earlier, each SME will have its own instance and database. The usage data can be administered for each SME and aggregated with cloud and network consumption. This data can be used to realize the accounting service and other generic platform services. The accounting service is present in Microsoft Azure. Due to practical time constraints, the decision is made to integrate usage data from the Kubernetes cluster in a later stage.

7.4 Case study: Emons Group

In line with **Section 6.5,** this section documents the results of case-based research at Emons.

Subsection 7.4.1 validates the IA design canvas and design workshop	**Step 4 and 5 of DSRM**
Subsection 7.4.2 validates the implementation guidelines in a pilot project	Demonstration
Subsection 7.4.3 evaluates the pilot using the adoption framework	Validation
Subsection 7.4.4 validates the improved implementation guidelines in a project	
Subsection 7.4.5 evaluates the project results using the adoption framework	
Subsection 7.4.6 discusses current work in progress	

7.4.1 Design workshop

As part of the ICCOS project, case study research is conducted at Emons, a family owned LSP in the Netherlands, for experimental development of agents and validation of the industry platform and supporting artefacts. First, a design workshop was organized to answer the question: How can Emons utilize AI to reduce empty milage? In this design workshop, the IA design canvas was used together with developed workshop materials. **Table 17** provides an overview of the workshop participants.

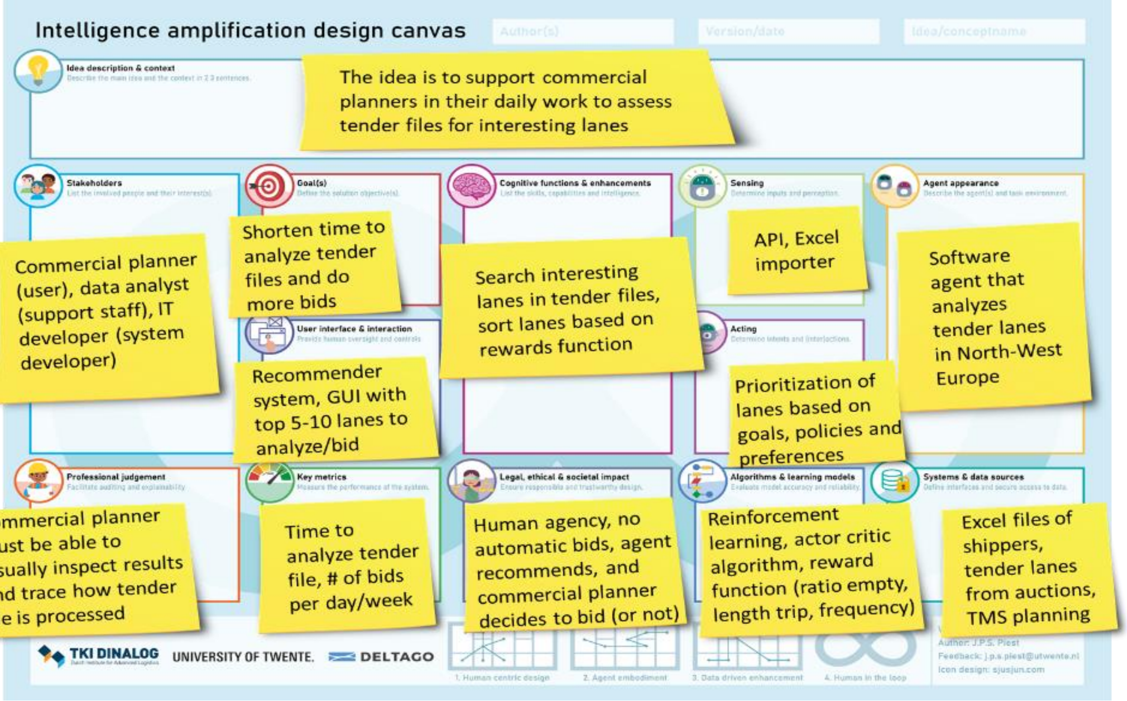
Participant	Organization	Background	Experience	System role(s)
Director	Emons	Master in Business Economics	28 years in logistics	Purchaser
IT Manager	Emons	Master in Business Informatics	25 years in logistics and IT	Support staff, purchaser
Business process analyst	Emons	Bachelor Logistics Engineering	7 years in logistics	User, system admin
Data scientist	Bullit Digital	Master in Business Information Technology	5 years in IT	Developer
Researcher	University of Twente	Master in Supply Chain Management	3 years in academia and 10 years in IT	Technical management

Table 17: Design canvas workshop participants.

The workshop agenda is included in **Appendix J**. During a one-day workshop, a total of 49 use cases were ideated for applications of AI at Emons as shown in **Figure 47**. Next, 5 agents were conceptualized by the workshop participants using the IA design canvas.

Figure 47: Design canvas workshop at Emons.

Figure 48 illustrates the use of the IA design canvas to conceptualize the smart tendering agent.



Intelligence amplification design canvas

Author(s)

Version/date

Idea/conceptname

Idea description & context
Describe the main idea and the context in 2-3 sentences.

The idea is to support commercial planners in their daily work to assess tender files for interesting lanes

Stakeholders
List the involved people and their interest(s).

Commercial planner (user), data analyst (support staff), IT developer (system developer)

Goal(s)
Define the solution objective(s).

Shorten time to analyze tender files and do more bids

User interface & interaction
Provide human oversight and controls

Recommender system, GUI with top 5-10 lanes to analyze/bid

Cognitive functions & enhancements
List the skills, capabilities and intelligence.

Search interesting lanes in tender files, sort lanes based on rewards function

Sensing
Determine inputs and perception.

API, Excel importer

Acting
Determine intents and (inter)actions.

Prioritization of lanes based on goals, policies and preferences

Agent appearance
Describe the agent(s) and task environment.

Software agent that analyzes tender lanes in North-West Europe

Professional judgement
Facilitate auditing and explainability.

Commercial planner must be able to visually inspect results and trace how tender file is processed

Key metrics
Measure the performance of the system.

Time to analyze tender file, # of bids per day/week

Legal, ethical & societal impact
Ensure responsible and trustworthy design.

Human agency, no automatic bids, agent recommends, and commercial planner decides to bid (or not)

Algorithms & learning models
Evaluate model accuracy and reliability.

Reinforcement learning, actor critic algorithm, reward function (ratio empty, length trip, frequency)

Systems & data sources
Define interfaces and secure access to data.

Excel files of shippers, tender lanes from auctions, TMS planning

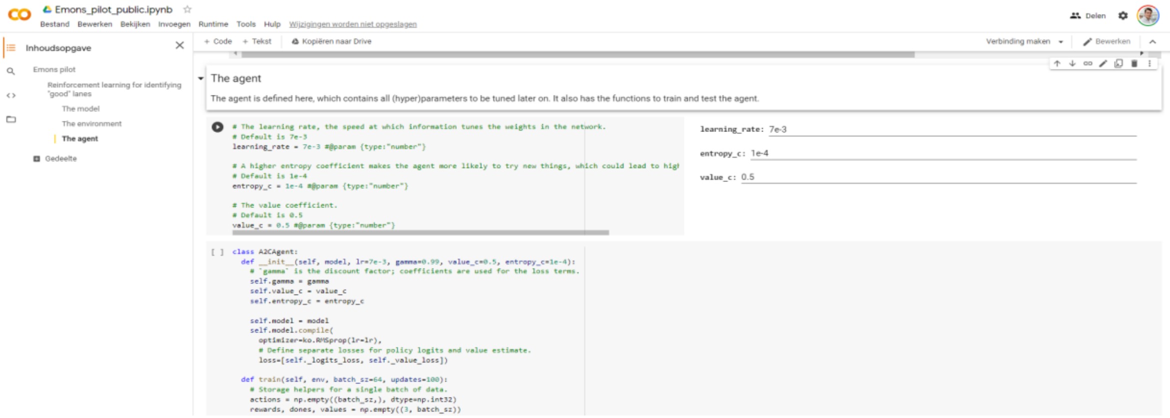
Author: J.P.S. Piest
Feedback: j.p.s.piest@utwente.nl
Icon design: sjusjun.com

Figure 48: Design canvas created to conceptualize the smart tendering agent.

At the end of the workshop, the use of the design canvas and supporting workshop was evaluated. The results of the evaluation of the design canvas and workshop are included in **Appendix J**. The design workshop is further developed within the Data science for Logistics Innovation (DALI) learning community. The results and findings are presented in **Subsection 7.5.1**.

7.4.2 Pilot project: smart tendering agent

Based on the design workshop, 1 use case was selected based on mutual decision for a pilot project to explore the use of RL and provide decision support for the order tendering process. The management supported the initiative and a team was formed to support the pilot project and experimental development of a smart tendering agent. The core team consisted of the business process analyst of Emons and data scientist of Bullit Digital. The business process analyst involved planners to collect input for the pilot project. The management was involved at the start and during the presentation of the results. The IA design canvas workshop followed the first and second implementation guidelines and resulted in a backlog and project plan for the selected use case to be developed. Using Google Colab, a prototype RL agent was developed for Emons by the development team to analyse tender files as shown in **Figure 49**.



The agent

The agent is defined here, which contains all (hyper)parameters to be tuned later on. It also has the functions to train and test the agent.

```
# The learning rate, the speed at which information tunes the weights in the network.
# Default is 7e-3
learning_rate = 7e-3 #@param {type:"number"}

# A higher entropy coefficient makes the agent more likely to try new things, which could lead to higl
# Default is 1e-4
entropy_c = 1e-4 #@param {type:"number"}

# The value coefficient.
# Default is 0.5
value_c = 0.5 #@param {type:"number"}
```

learning_rate: 7e-3

entropy_c: 1e-4

value_c: 0.5

```
[ ] class A2CAgent:
      def __init__(self, model, lr=7e-3, gamma=0.99, value_c=0.5, entropy_c=1e-4):
        # `gamma` is the discount factor; coefficients are used for the loss terms.
        self.gamma = gamma
        self.value_c = value_c
        self.entropy_c = entropy_c

        self.model = model
        self.model.compile(
          optimizer=ko.RMSprop(lr=lr),
          # Define separate losses for policy logits and value estimate.
          loss=[self._logits_loss, self._value_loss])

      def train(self, env, batch_sz=64, updates=100):
        # Storage helpers for a single batch of data.
        actions = np.empty((batch_sz,), dtype=np.int32)
        rewards, dones, values = np.empty((3, batch_sz))
```

Figure 49: RL agent for smart tendering created in Google colab.

A representative example file was shared with 903 tender lanes. The example file was imported and visualized according to the third guideline as shown in **Figure 50**.

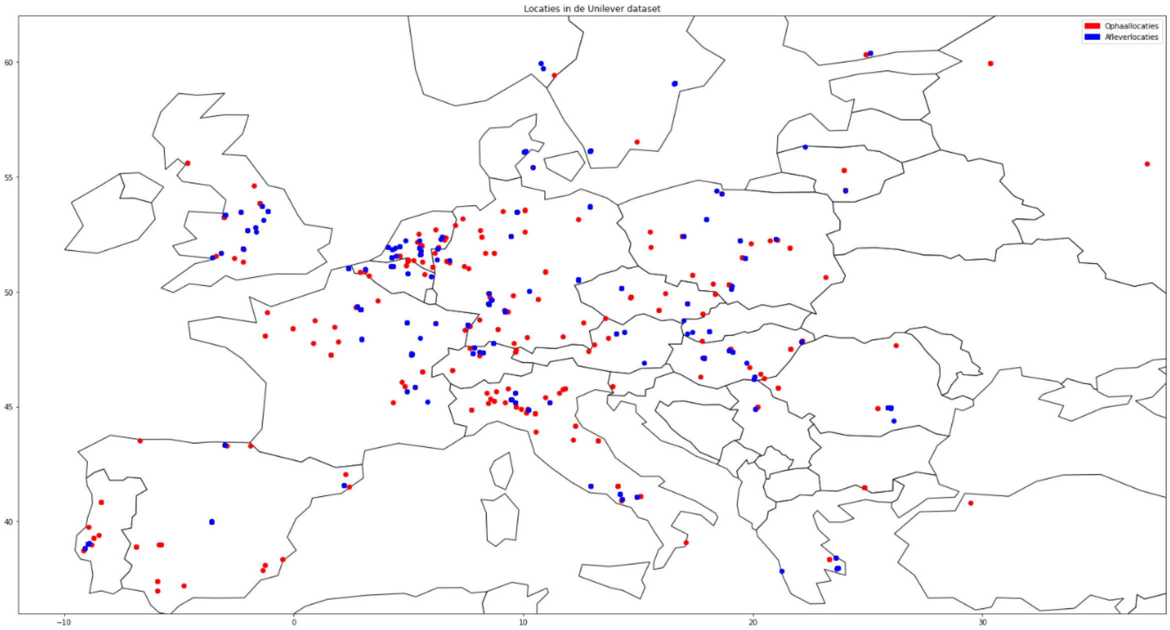


Figure 50: Visualization of the obtained dataset.

Next, the locations are clustered to narrow down the search space and create an environment in which the agent will be trained. **Figure 51** illustrates how the initial set of locations is clustered using unsupervised learning.

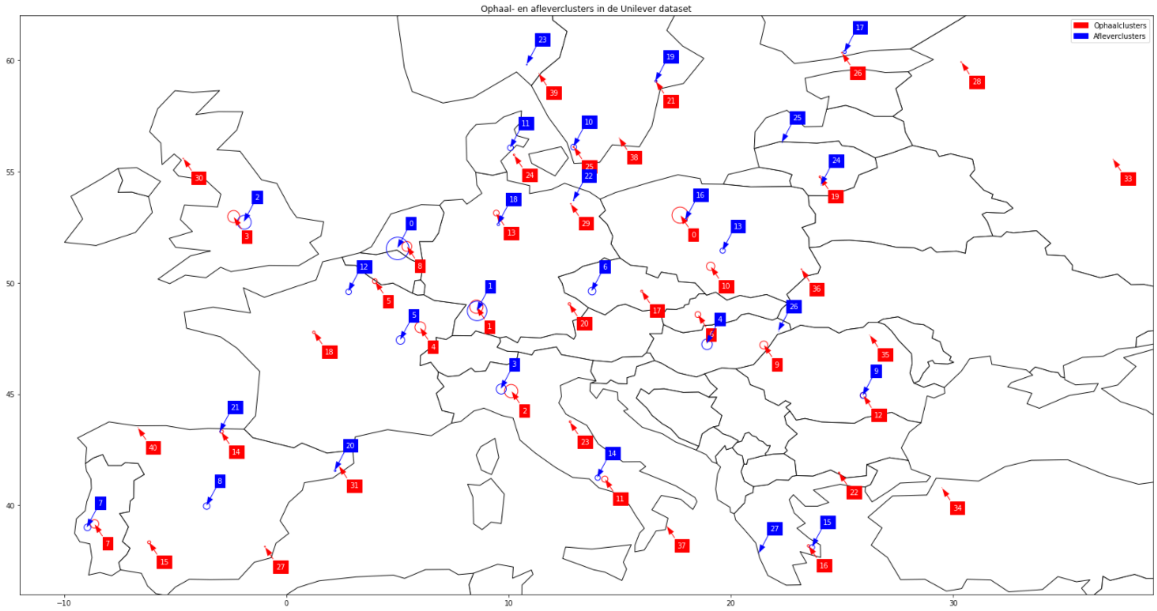


Figure 51: Clustering of locations in the obtained dataset.

The results were validated with end-users and provided the starting point to create the environment, model, and rewards systems based on the fourth guideline. Next, based on the fifth guideline, a neural network was selected by the development team and trained to learn to see possible routes using one-hot encoding. **Figure 52** illustrates how the agent randomly tries combinations of locations. The results are stored for each iteration.

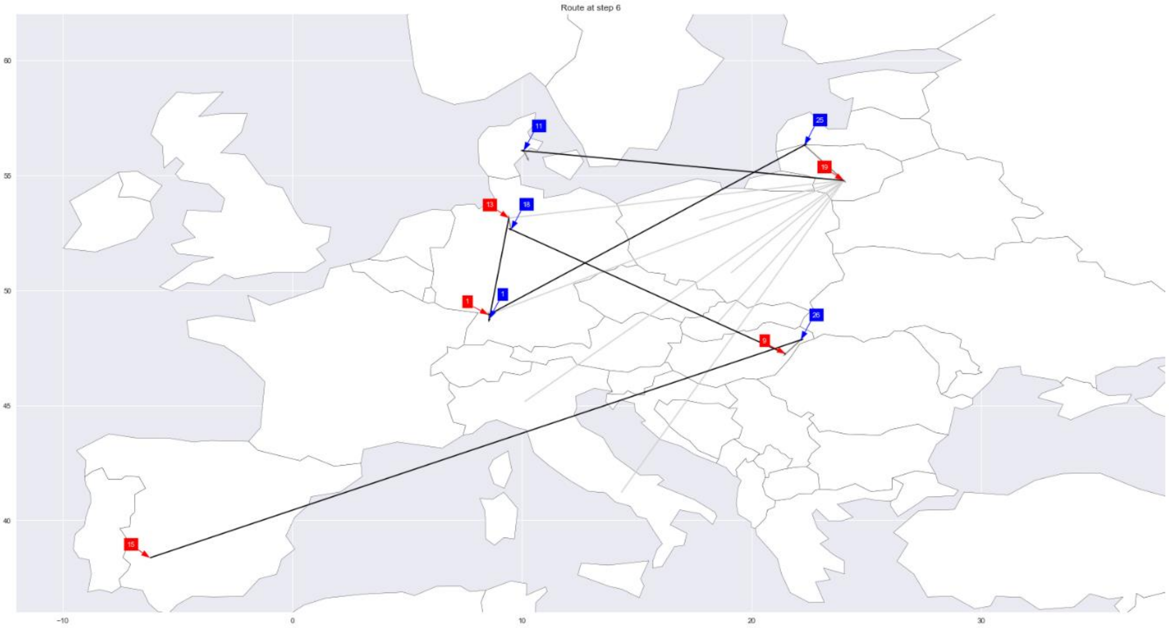


Figure 52: Visualization of the agent results during training.

Following the sixth guideline, the agent was updated to remember the last 5 steps and the advantage actor critic algorithm is selected for training and simulation. **Figure 53** illustrates how the performance increases based on training and simulation.

Figure 53: Screenshot of the RL model performance based on simulation.

The agent performance is assessed using 3 criteria: 1) the length of the trip, 2) the frequency of the trip, and 3) the ratio empty. **Table 18 and 19** present the results of respectively the initial untrained model and the trained model.

Pick-up	Drop-off	New trip?	Freq.	Ratio util.	Dist. score	Freq. score	Score
15	26	no	–	–	–	–	**-20**
9	18	no	–	–	–	–	**-20**
13	1	yes	40	7,68	1,02	5,67	**14,36**
1	25	no	–	–	–	–	**-20**
19	11	yes	25	5,68	2,62	3,54	**11,86**
							-33,78

Table 18: Initial agent results based on untrained model.

Pick-up	Drop-off	New trip?	Freq.	Ratio util.	Dist. score	Freq. score	Score
22	1	yes	25	7,67	3,95	5,42	**17,04**
1	9	yes	25	9,80	3,23	5,42	**18,44**
12	7	yes	20	6,09	5	4,33	**15,42**
7	9	yes	25	9,80	5	4,33	**19,13**
12	1	yes	24	7,68	2,92	4,5	**15,10**
							85,13

Table 19: Agent results based on trained model.

Following the seventh guideline, the business impact was assessed, and the results were evaluated based on the goals and expectations of the pilot project. However the pilot project is successfully delivered for this specific use case, the implementation is put on hold because of the efforts required to integrate the internal system, which was in the process of being updated to a newer version. This pilot project demonstrates the use of the implementation guidelines and potential of RL for smart tendering. Next, the pilot results are evaluated.

7.4.3 Pilot project evaluation and learnings

Table 20 evaluates the pilot results using the adoption framework.

Process	Output, metrics, KPIs	Pilot	Learnings
Initiation	C-level commitment	Yes, initiative supported.	Planning of the pilot and milestones is important to communicate to stakeholders
	Business case Project charter	Created document upfront and pilot agreements.	Multi-disciplinarity is important to align business expectations.
	Projects in progress Backlog	1 pilot, 5 ideas conceptualized, 49 ideas on backlog.	Design canvas and workshop are useful, step toward implementation can be improved.
IT alignment	€ OPEX € CAPEX # Hours internal # Hours external	€ 250,- cloud p/month. € 0,- cash investments. 80 hours Emons. 160 hours Bullit Digital.	Initial set-up of Emons environment (GUI, OTM APIs, OTM database) in 2 hours.
IT conversion	# Agents developed # Agents in use	1 agent developed for pilot, no agent in use.	Colab documentation and visualization supports better understanding.
IT use	Score card per agent IA effects, candidates: - User efficiency - Cognitive-task fit	3 performance criteria.	Agent is trained for 1 specific tender file. Requires harmonization of tender files.

	- User adoption - User satisfaction		
Competitiveness building	Score card per process, candidates: - Capacity / output - Lead times - Transaction cost	No implementation.	Embodiment of the agent in the GUI is required for end-user involvement.
Benefits realization management	Score card for organization, candidates: - Overall effectiveness - Operational efficiency gains - IT costs and savings - Value of benefits - Return on Investment - Payback period	No benefits realized.	Learnings from experimental use of AI/RL.

Table 20: Measurement and monitoring of adoption and benefits realization in a pilot at Emons.

The implementation guidelines have proven to be useful to support the implementation processes related to initiation, IT alignment, IT conversion, and IT use in the pilot project at Emons. In particular the visualizations contribute to better understanding of involved stakeholders. The step towards actual implementation and use of the agent in an operational environment requires further development and systems integration. More specifically, the agent must be trained based on multiple tender files, embedded in the GUI, and connected to source systems. The experimental use provided interesting insights in the use of AI/RL for the smart tendering use case. Generalizing this use case requires harmonization of tender files, standardization of the input data, comparison of the current model with alternative data-driven approaches, and additional case studies. More specifically, score cards need to be developed to measure and compare current process performance without agents to agent impact. Future projects should start with also consider conditions of practice and requirements for deploying AI/RL algorithms on a larger scale at the start of a project.

7.4.4 Project: dynamic planning and refuelling

In the ReAL project, additional case study research is conducted for experimental development of agents and validation of the industry platform and supporting artefacts. **Table 21** presents an overview of the involved project members. Following the IT dominant BIE, end-users are involved during the development and implementation process.

Member	Organization	Background	Experience	System role(s)
Director	Emons	Master in Business Economics	28 years in logistics	Purchaser
IT Manager	Emons	Master in Business Informatics	25 years in logistics and IT	Support staff, purchaser
Data Service Centre Lead	Emons	Master in Business Administration	3 years in logistics, 8 years in industry	System admin
Business process analyst	Emons	Master in Transport and Planning (Civil Engineering)	2 years in logistics	Support staff
Data analyst	Emons	Bachelor in Industrial Engineering & Management	1 year in logistics	Support staff
Postdoctoral researcher	University of Twente	PhD in Operations Research	6 years in academia	Researcher, developer
Data scientist	Bullit Digital	Master in Business Information Technology	5 years in IT	Developer
Infrastructure specialist	Bullit Digital	Master in Business Information Technology	5 years in IT	Developer
Researcher	University of Twente	Master in Supply Chain Management	3 years in academia and 10 years in IT	Technical management

Table 21: Project members involved in the ReAL project.

Following the first guideline, a set of 14 use cases is ideated by involved stakeholders from Emons and discussed with experts during the monthly online consortium meetings. Based on mutual consent, the use case for dynamic planning and refuelling is selected. Following the second guideline, a project initiation document was created and complemented with a task list in Microsoft Teams. The main idea is to reduce the fuel expenses. Current monthly fuel costs are approximately 1 million euro. Emons has preferred fuel suppliers and contractual agreements. The current decisions are taken by fleet managers and based upon experience. There is no decision support tool. The decisions are expected not to be optimal as they involve rerouting and long waiting times. The goal is to develop a software agent that can filter fuel stations along the route and provide decision support where to refuel. The goal is to make decision-making dynamic by incorporating the current fuel level in the truck at a particular point in time which can be validated by the fleet managers and compared to current decision-making. Building on this, the management would like to prescribe refuelling at preferred fuel stations and/or where the net cost is less. Based on stakeholder interaction, the operational scenario is visualized and linked to OTM entities as shown in **Figure 54**. The operational scenario is based on an individual route but should be capable of making decisions based on a series of routes in a later stage. The scalability aspects are important given the fact that Emons has a fleet of approximately 800 trucks.

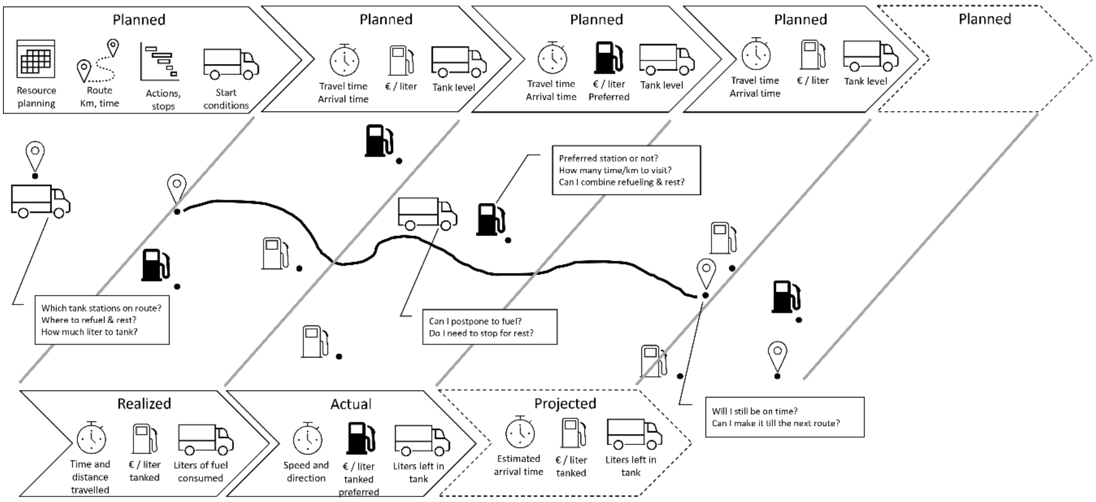


Figure 54: Operational scenario and related OTM entities for dynamic planning and refuelling agent.

The operational scenario combines planning data from the TMS with dynamic data from the board computer. This way the planned route, actions, stops and start conditions can dynamically be monitored during the actual transport. Two aspects of the planning are incorporated in the solution concept: refuelling and resting. During the execution, realized trajectories can be used to estimate arrival times, fuel consumption, and tank levels. Building on the operational scenario, the agent environment, model, and rewards system are conceptualized as shown in **Figure 55**.

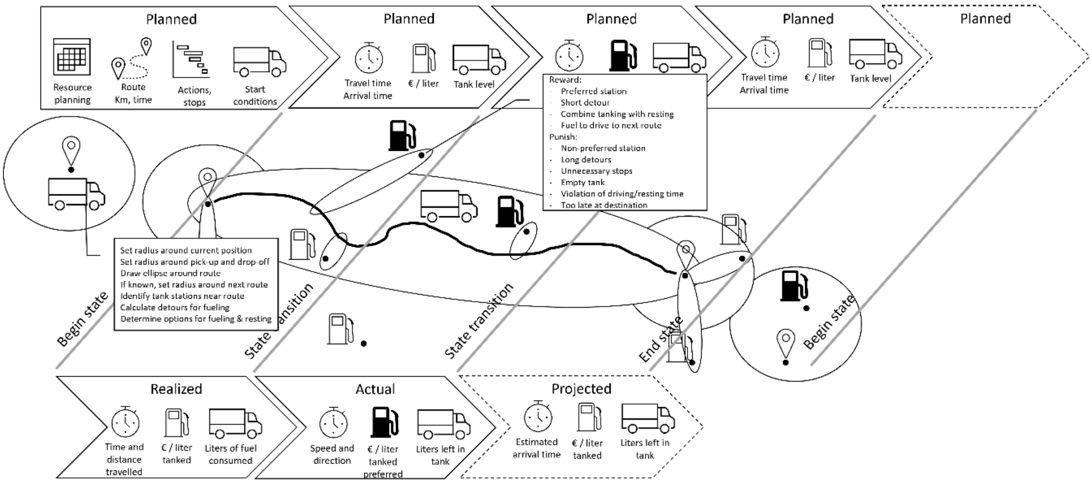
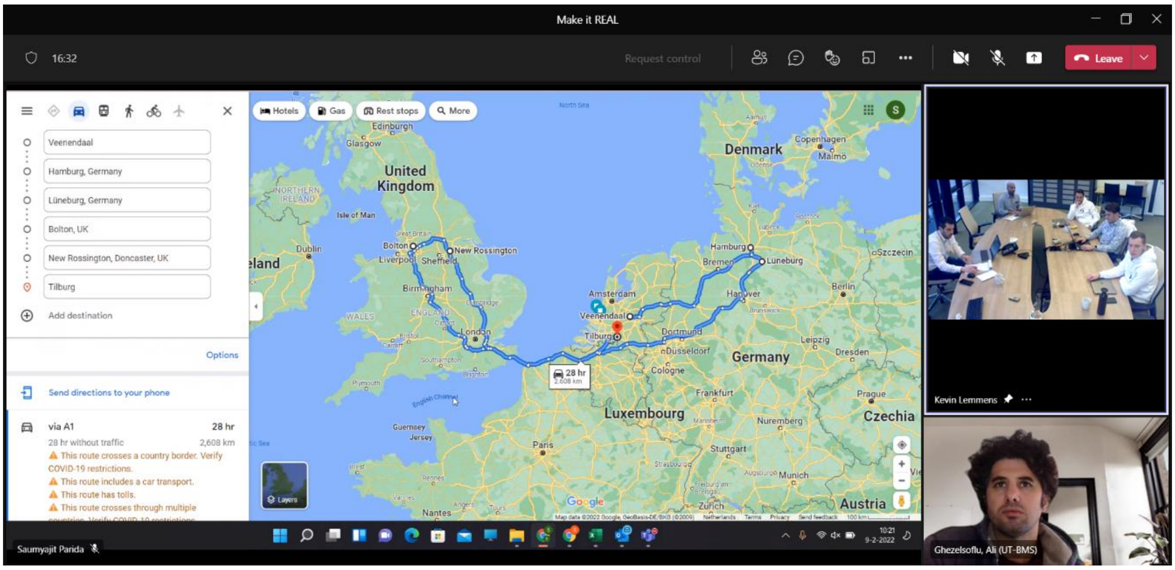


Figure 55: Conceptualization of the agent for dynamic planning and refuelling.

Following the third guideline, the required data are collected and visualized. A dataset is prepared by Emons and meetings took place to explain the properties. This resulted in a file with historical order data, trip data, and a file with 338 fuel stations throughout North-West Europe. In addition, the board computer activities are exported to a separate file. In consultation with the fleet managers, the first development iteration should focus on repeating orders. The order data are filtered by frequency/occurrence and resulted in three lanes. The following three lanes are visualized using Google Maps: Hamburg to Vaihingen, Köln/Porz to Anadia and Torgau/Repitz to Kjellerup. To be able to compare the results, the fuel stations along these lanes are marked in the dataset. One combination of trips is selected and presented during a meeting, as shown in **Figure 56**, as the starting point to develop a small environment for experimental development of the agent.



Veenendaal
Hamburg, Germany
Lüneburg, Germany
Bolton, UK
New Rossington, Doncaster, UK
Tilburg
Add destination

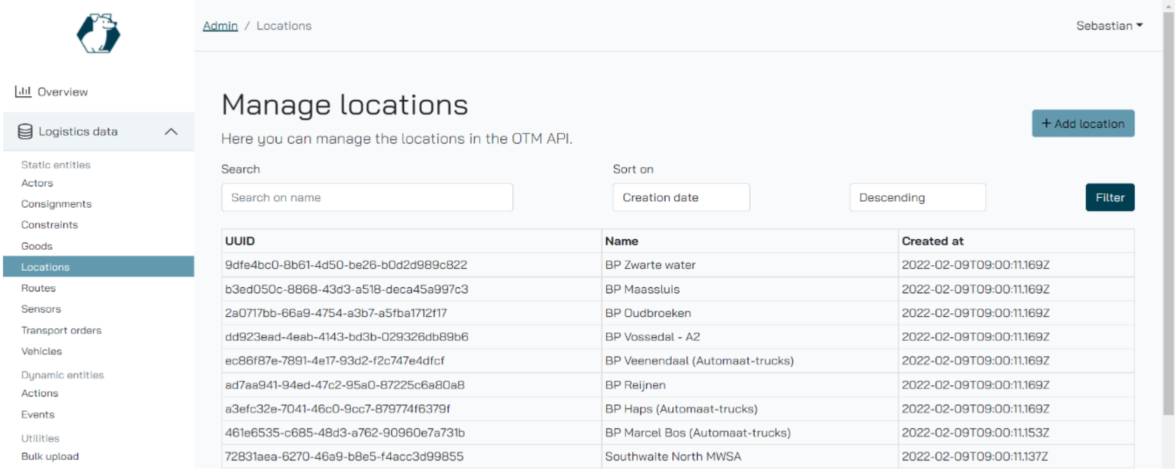
Options

Send directions to your phone

via A1 28 hr
28 hr without traffic 2,608 km
This route crosses a country border. Verify COVID-19 restrictions.
This route includes a car transport.
This route has tolls.
This route crosses through multiple

Figure 56: Example of a shipment with multiple stops.

The agent should be able to identify fuel stations along the route. For the first iteration the distance of the fuel station to the route is sufficient. During a one-day session at Emons, the development team managed to map the provided data to the OTM and import the data using the file import. **Figure 57** shows a fragment of the imported Fuel stations as Locations.



Manage locations

Here you can manage the locations in the OTM API.

Search: Search on name
Sort on: Creation date
Descending

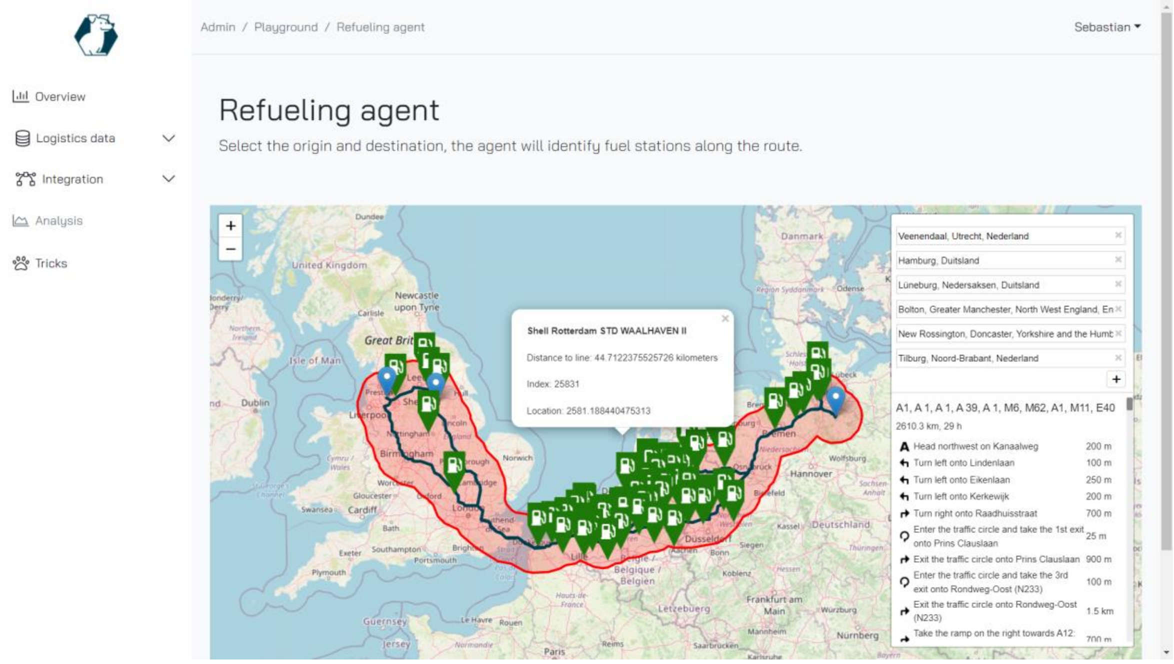
UUID	Name	Created at
9dfe4bc0-8b61-4d50-be26-b0d2d989c822	BP Zwarte water	2022-02-09T09:00:11.169Z
b3ed050c-8868-43d3-a518-deca45a997c3	BP Maassluis	2022-02-09T09:00:11.169Z
2a0717bb-66a9-4754-a3b7-a5fba1712f17	BP Oudbroeken	2022-02-09T09:00:11.169Z
dd923ead-4eab-4143-bd3b-029326db89b6	BP Vossedal - A2	2022-02-09T09:00:11.169Z
ec86f87e-7891-4e17-93d2-f2c747e4dfcf	BP Veenendaal (Automaat-trucks)	2022-02-09T09:00:11.169Z
ad7aa941-94ed-47c2-95a0-87225c6a80a8	BP Reijnen	2022-02-09T09:00:11.169Z
a3efc32e-7041-46c0-9cc7-879774f6379f	BP Haps (Automaat-trucks)	2022-02-09T09:00:11.169Z
461e6535-c685-48d3-a762-90960e7a731b	BP Marcel Bos (Automaat-trucks)	2022-02-09T09:00:11.153Z
72831aea-6270-46a9-b8e5-f4acc3d99855	Southwaite North MWSA	2022-02-09T09:00:11.137Z

Figure 57: Result of the import of fuel stations as locations.

The supplied logistics data was imported in the industry platform based on the OTM entities (actors, vehicles, consignments, routes, transport orders, locations) as a starting point to develop the agent. The board computer data will be imported in a later stage. At the end of the day, a prototype was shown to visualize routes on the map with a radius as shown in **Figure 58**.

Figure 58: Prototype demonstration at the end of the session at Emons.

Based on fourth guideline the feedback of the Emons team, the agent was created and tested based on the selected trade lanes and a shipment with a combination of trips, shown in **Figure 59**.



Refueling agent

Select the origin and destination, the agent will identify fuel stations along the route.

Shell Rotterdam STD WAALHAVEN II

Distance to line: 44.7122375525726 kilometers

Index: 25831

Location: 2581.188440475313

Veenendaal, Utrecht, Nederland

Hamburg, Duitsland

Lüneburg, Nedersaksen, Duitsland

Bolton, Greater Manchester, North West England, En

New Rossington, Doncaster, Yorkshire and the Humb

Tilburg, Noord-Brabant, Nederland

A1, A 1, A 1, A 39, A 1, M6, M62, A1, M11, E40

2610.3 km, 29 h

Head northwest on Kanaalweg	200 m
Turn left onto Lindenlaan	100 m
Turn left onto Eikenlaan	250 m
Turn left onto Kerkewijk	200 m
Turn right onto Raadhuisstraat	700 m
Enter the traffic circle and take the 1st exit onto Prins Clauslaan	25 m
Exit the traffic circle onto Prins Clauslaan	900 m
Enter the traffic circle and take the 3rd exit onto Rondweg-Oost (N233)	100 m
Exit the traffic circle onto Rondweg-Oost (N233)	1.5 km
Take the ramp on the right towards A12	700 m

Figure 59: Refuelling agent demonstration based on supplied logistics data.

The refuelling agent is incorporated in the GUI for testing and validation with involved stakeholders based on the selected trade lanes. Users can test the agent by entering an origin and destination. The agent calculates the route, draws a radius, selects fuel stations within the radius, and visualizes the result on the map. The results of the three trade lanes are included in **Appendix K**. For the initial test, the agent results satisfy the requirements for decision support. Adding actual distances, driving times, and turnaround times can further improve the results. Embodiment in the GUI contributes to involving end-users in an early development stage. Unfortunately, at the time of writing, the development work was not fully completed. However, the intermediate results are evaluated by involved stakeholders, included in **Appendix K**, and evaluated in the **Subsection 7.4.5**.

7.4.5 Evaluation intermediate results and learnings

Table 22 presents the results of measurement and monitoring of benefits realization processes.

Process	Output, metrics, KPIs	Project	Learnings
Initiation	C-level commitment	Yes, initiative supported.	Planning of the project is improved compared to the pilot.
	Business case Project charter	Created document upfront with project agreements and action list in MS Teams.	Incorporating full scale deployment requirements, data and operational scenario contributed to clear concept and case.
	Projects in progress Backlog	1 project running, 1 pilot completed, 6 ideas conceptualized, 62 ideas on backlog.	The project added 13 use cases to the backlog, 1 use case is selected for implementation.
IT alignment	€ OPEX € CAPEX # Hours internal # Hours external	€ 250,- cloud p/month € 0,- no cash investments Hours Emons, UT and Bullit Digital to be reported.	Initial estimated time and efforts were unrealistic. Actual implementation will require significant efforts.
IT conversion	# Agents developed # Agents in use	1 agent developed No agent in use.	Embodiment in the GUI contributes to involving end-users.
IT use	Score card per agent IA effects, candidates: - User efficiency - Cognitive-task fit - User adoption	Clear goal and supporting set of rewards and penalties defined.	Visual results are shown and distance to route is incorporated. Scorecard should also

	- User satisfaction		be incorporated in GUI for end-users.
Competitiveness building	Score card per process, candidates: - Time to decide - Detour in km / time - Time to refuel	Process metrics need to be made explicit to measure current process performance and outcome.	A workshop with fleet managers should be planned to gather requirements for large scale use of the agent.
Benefits realization management	Score card for fuel cost saving.	No benefits realized.	Learnings from experimental use of AI/RL.

Table 22: Measurement and monitoring of adoption and benefits realization in a project at Emons.

Building on the experience from the pilot project, the implementation guidelines were applied to develop a new agent for dynamic planning and refuelling. The main learnings from the pilot are transferred and directly added value. The embodiment in the GUI especially contributed to early involvement of stakeholders and validating the agent concept and functioning with real data. Thinking in terms of scalability also contributed to better initial expectations, scenario development, and collecting the right data. Decomposing the implementation in smaller parts has proven effective to deliver a working agent, which produced promising first results for the three repeating trade lanes. The agent returned good results, but the runtime performance dropped for combined trips. The performance metrics will be analysed to prepare large scale deployment and use. Initial results are encouraging, however the actual implementation will require significant time and efforts. Developing new agents requires significant efforts from highly trained subject matter experts and domain experts. For future projects it is recommended to add milestones and supporting decision-making criteria to inform and involve management during the process.

7.4.6 Current work in progress

Current work takes place in the ReAL project to implement the dynamic planning and refuelling agent. In current research, a Markov decision process and mixed integer linear programming model are developed to extend the current agent. Current development work focuses on importing historical board computer data to develop simulation models as a foundation for dynamic planning and refuelling decisions. Together with Emons, the systems integration requirements are gathered.

7.5 Impact development

This section documents the results of impact development as part of the learning community.

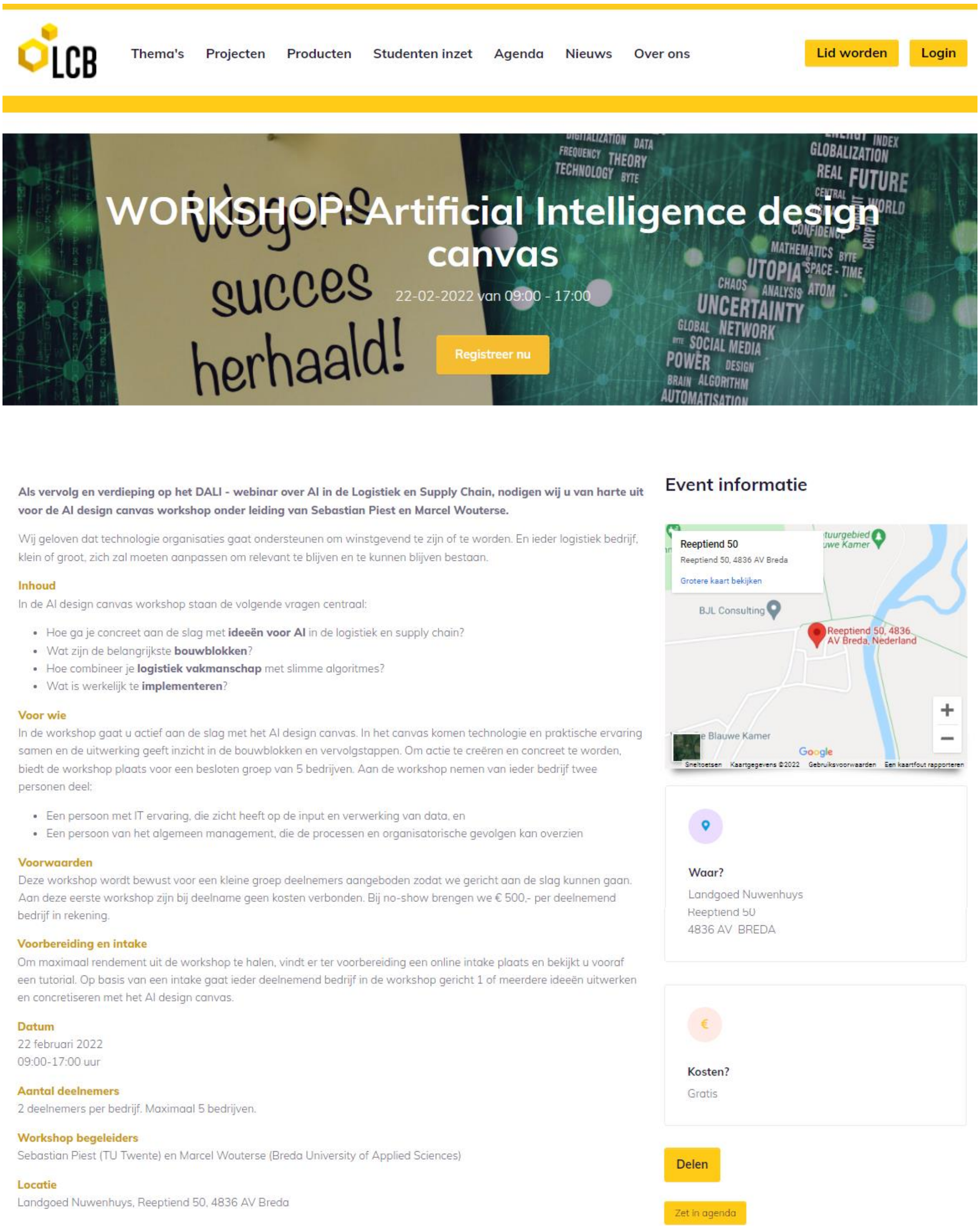
Subsection 7.5.1 describes the design workshop that is developed for the industry	**Step 4 and 5 of DSRM**
Subsection 7.5.2 contains the blended workshop design for enhanced learning	Demonstration
Subsection 7.5.3 discusses current work in progress	Validation

7.5.1 Design canvas workshops for the industry

Together with Deltago and Breda University of Applied Sciences, 3 design workshops were organized for members of Logistics Community Brabant (LCB) as part of the DALI learning community.

7.5.1.1 Contents and organization

Figure 60 presents the design canvas workshop contents and organization (in Dutch).



Als vervolg en verdieping op het DALI - webinar over AI in de Logistiek en Supply Chain, nodigen wij u van harte uit voor de AI design canvas workshop onder leiding van Sebastian Piest en Marcel Wouterse.

Wij geloven dat technologie organisaties gaat ondersteunen om winstgevend te zijn of te worden. En ieder logistiek bedrijf, klein of groot, zich zal moeten aanpassen om relevant te blijven en te kunnen blijven bestaan.

Inhoud
In de AI design canvas workshop staan de volgende vragen centraal:

- Hoe ga je concreet aan de slag met **ideeën voor AI** in de logistiek en supply chain?
- Wat zijn de belangrijkste **bouwblokken**?
- Hoe combineer je **logistiek vakmanschap** met slimme algoritmes?
- Wat is werkelijk te **implementeren**?

Voor wie
In de workshop gaat u actief aan de slag met het AI design canvas. In het canvas komen technologie en praktische ervaring samen en de uitwerking geeft inzicht in de bouwblokken en vervolgstappen. Om actie te creëren en concreet te worden, biedt de workshop plaats voor een besloten groep van 5 bedrijven. Aan de workshop nemen van ieder bedrijf twee personen deel:

- Een persoon met IT ervaring, die zicht heeft op de input en verwerking van data, en
- Een persoon van het algemeen management, die de processen en organisatorische gevolgen kan overzien

Voorwaarden
Deze workshop wordt bewust voor een kleine groep deelnemers aangeboden zodat we gericht aan de slag kunnen gaan. Aan deze eerste workshop zijn bij deelname geen kosten verbonden. Bij no-show brengen we € 500,- per deelnemend bedrijf in rekening.

Voorbereiding en intake
Om maximaal rendement uit de workshop te halen, vindt er ter voorbereiding een online intake plaats en bekijkt u vooraf een tutorial. Op basis van een intake gaat ieder deelnemend bedrijf in de workshop gericht 1 of meerdere ideeën uitwerken en concretiseren met het AI design canvas.

Datum
22 februari 2022
09:00-17:00 uur

Aantal deelnemers
2 deelnemers per bedrijf. Maximaal 5 bedrijven.

Workshop begeleiders
Sebastian Piest (TU Twente) en Marcel Wouterse (Breda University of Applied Sciences)

Locatie
Landgoed Nuwenhuys, Reeptiend 50, 4836 AV Breda

Waar?
Landgoed Nuwenhuys
Reeptiend 50
4836 AV BREDA

Kosten?
Gratis

Figure 60: Design canvas workshop for members of the Logistics Community Brabant.

The design canvas workshop is prepared, delivered, and evaluated in three steps as shown in **Figure 61**. All workshops are evaluated using a feedback form, which are included in **Appendix L**.

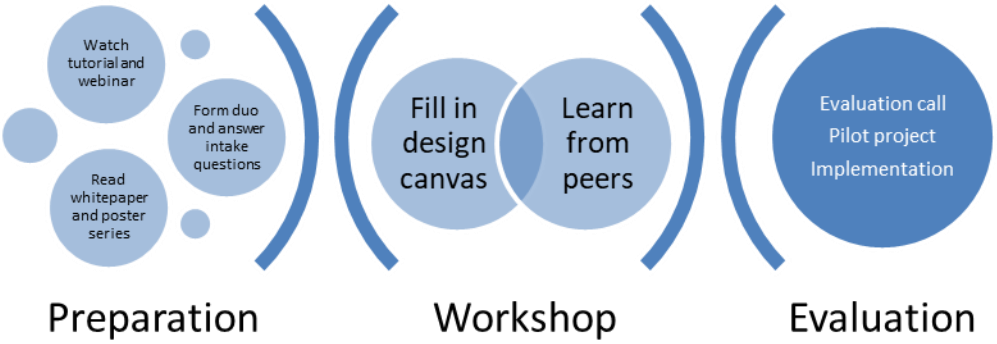


Figure 61: Overview of preparation, workshop activities, and evaluation.

The design canvas workshop was published in the event calendar of LCB and DALI. Invitations were sent directly to DALI participants, shared in the LCB community, and wider via social media. After verification, participants received practical information about the design canvas workshop, including reading materials and links to webinars and supporting resources. An intake was conducted online via MS Teams and participants received a short questionnaire. Four questions were asked individually to learn about the background, current position, pre-knowledge and experience. In addition, participants were asked to briefly summarize the idea and share expectations or questions for the design workshop. During the intake, the input was discussed, links to resources were shared, and the design canvas workshop agenda was discussed in more detail to align expectations.

7.5.1.2 1st workshop

The first workshop was organized for 6 companies with 11 participants as shown in **Figure 62**.

Figure 62: Impression of the first design canvas workshop for the DALI learning community.

The first workshop was planned in the morning and is assessed with a score of 7.3 out of 10. The main improvement, mentioned by multiple participants, was to increase the duration to a full day instead of a morning so that there is more room to discuss all contents, present results to other groups to learn from each other, and run multiple design iterations.

7.5.1.3 2nd workshop

The second workshop was organized for 5 companies with 8 participants as shown in **Figure 63**.

Figure 63: Impression of the second design canvas workshop for the DALI learning community.

The second workshop is assessed with a score of 8.4 out of 10. Based on the evaluation of the first workshop, a full day was planned. This turned out very well and gave more time to complete the design canvas in three iterations and let participants present their ideas to learn from each other. Providing more tangible examples, like the presented Emons case study, prior to the workshop can contribute to better understanding.

7.5.1.4 3rd workshop

The third workshop was organized for 3 companies with 6 participants as shown in **Figure 64**.

Figure 64: Impression of the third design canvas workshop for the DALI learning community.

The third workshop is assessed with a score of 7.6 out of 10. Building on second workshop, a full day was planned again and the number of slides was reduced to focus on discussion and interaction. This worked out well and participants indicated the learning outcomes in the evaluations. Although a variety of examples and reading materials were provided prior to the workshop, participants kept emphasizing that more practical examples contribute to better understanding.

7.5.1.5 Evaluation

Based on the three design canvas workshops, the evaluations were discussed with the project manager of DALI. The average score of the three workshops is 7.8 out of 10 based on the assessment of 25 workshop participants from 14 companies. 22 out of 25 participants recommend the design canvas workshop to a colleague. The intake and preparation has an average score of 4 out of 5. The content has an average score of 4 out of 5. The balance of theory and application has an average score of 3.7 out of 5. Stimulating thinking and acting has a score of 4.4 out of 5. The teaching style is assessed with a 4.4 out of 5 score. The level of interaction is assessed with a score of 4 out of 5.

The evaluation forms were discussed with the project manager of DALI. Overall, the project manager was satisfied with the evaluations and received positive feedback in the follow-up calls. The following improvements can be made. First and most important, a knowledge base with practical examples and use cases can contribute to enhance the value of the design workshop. Second, an awareness course can be organized prior the design workshop. The first part of the in-company workshop at Emons can be considered to ideate use cases together. Moreover, based on interaction with participants of the design workshop, the project manager wants to establish a community of practice within the DALI programme to support selected companies with additional workshops, involvement of experts and students to actually implement their ideas, and share progress during intervision meetings. This community of practice is currently being designed.

Based on the evaluation and discussed improvements, a blended workshop design has been created to support digital enhanced learning. Deltago implemented a Learning Management System (LMS) to implement the blended workshop design. Learndash[33] is selected as LMS to provide the desired functionality to deliver (parts of) the design workshop online and streamline the preparation, workshop, and evaluation. Furthermore, this LMS can be used to establish a knowledge base and share workshop materials with participants using content dripping. This blended workshop is the starting point, to develop the community of practice and additional courses. Discussion forums, course points and leader boards can be used to develop a hybrid learning community platform.

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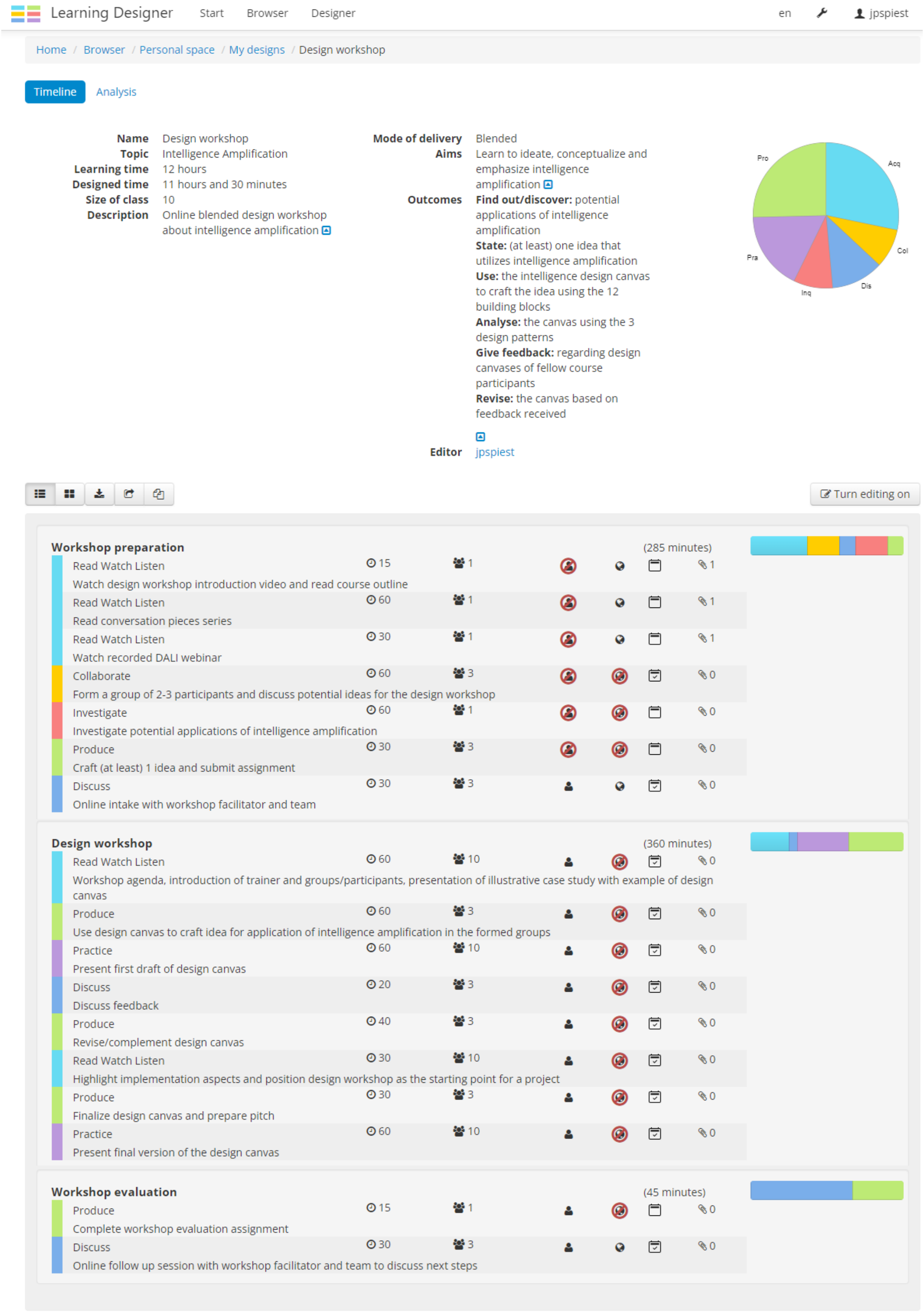
[33] https://www.learndash.com/

7.5.2 Blended workshop design

Based on the design canvas workshops, a blended learning design is created, shown in **Figure 65**.



Name Design workshop
Topic Intelligence Amplification
Learning time 12 hours
Designed time 11 hours and 30 minutes
Size of class 10
Description Online blended design workshop about intelligence amplification

Mode of delivery Blended
Aims Learn to ideate, conceptualize and emphasize intelligence amplification
Outcomes **Find out/discover:** potential applications of intelligence amplification
State: (at least) one idea that utilizes intelligence amplification
Use: the intelligence design canvas to craft the idea using the 12 building blocks
Analyse: the canvas using the 3 design patterns
Give feedback: regarding design canvases of fellow course participants
Revise: the canvas based on feedback received
Editor jpspiest

Workshop preparation (285 minutes)

Read Watch Listen	Watch design workshop introduction video and read course outline	15	1	1
Read Watch Listen	Read conversation pieces series	60	1	1
Read Watch Listen	Watch recorded DALI webinar	30	1	1
Collaborate	Form a group of 2-3 participants and discuss potential ideas for the design workshop	60	3	0
Investigate	Investigate potential applications of intelligence amplification	60	1	0
Produce	Craft (at least) 1 idea and submit assignment	30	3	0
Discuss	Online intake with workshop facilitator and team	30	3	0

Design workshop (360 minutes)

Read Watch Listen	Workshop agenda, introduction of trainer and groups/participants, presentation of illustrative case study with example of design canvas	60	10	0
Produce	Use design canvas to craft idea for application of intelligence amplification in the formed groups	60	3	0
Practice	Present first draft of design canvas	60	10	0
Discuss	Discuss feedback	20	3	0
Produce	Revise/complement design canvas	40	3	0
Read Watch Listen	Highlight implementation aspects and position design workshop as the starting point for a project	30	10	0
Produce	Finalize design canvas and prepare pitch	30	3	0
Practice	Present final version of the design canvas	60	10	0

Workshop evaluation (45 minutes)

Produce	Complete workshop evaluation assignment	15	1	0
Discuss	Online follow up session with workshop facilitator and team to discuss next steps	30	3	0

Figure 65: Blended design workshop created in Learning Designer.

The aim of the blended design is to utilize online learning platform functionality to streamline the preparation, workshop, and evaluation and distribute learning resources to workshop participants. The blended course design is created in Learning Designer and available online: https://v.gd/rv5lac

7.5.3 Current work in progress

This subsection highlights current work in progress.

7.5.3.1 Community of practice

Together with Deltago and LCB, a community of practice is currently being developed to extend the scope of the design canvas workshop and provide implementation guidance for a broader group of 5-10 SMEs over a period of 6 months. Additional workshop materials will be developed and the use cases that will be developed in this community of practice will be implemented in the industry platform to scale up results and contribute to realizing the envisioned broader societal impact.

7.5.3.2 National online AI awareness course for logistics

Recently, together with Martijn Neef, AI impact manager at TU Delft, I started to design the National online AI awareness course for Logistics for the NL AI Coalition. This online course is designed around 12 micro lectures of 15 minutes (total 3 hours) and is expected to contribute to realizing the envisioned broader societal impact. The planned launch of this awareness course is July 2022.

7.6 Summary and conclusion

This chapter demonstrated the industry platform in use. Following the design methodology, an expert panel consultation is conducted to verify the ideas and concepts of the industry platform and validate the architecture. Overall, the experts are positive about the industry platform and collective approach to reach a larger group of SMEs via a learning community. Some doubts and concerns were raised about the current state of OTM adoption and use of the industry platform in small enterprises. The industry platform instantiation displays the GUI, OTM APIs, OTM database, tool to develop agents, and repository to share re-usable agents among SMEs, and supporting infrastructure for provisioning. Tests show that the desired functionality works and the iterations facilitated improvement of the developed artefacts. In addition to testing with practitioners, the industry platform is tested by potential end-users. Case study research at Emons revealed a broad variety of use cases for AI and RL. The IA design canvas and workshop materials have proven useful to support the ideation and conceptualization process. The pilot project is used to validate the implementation guidelines and adoption framework to measure and monitor benefits realization. Further empirical research is taking place to develop and implement an agent for dynamic planning and refuelling at Emons. In addition to case-based research, the impact plan is used to reach a larger group of SMEs with design canvas workshops for the industry and developing a blended version of the design canvas workshop. Together with LCB, 3 workshops were organized in which 25 participants were enrolled on behalf of 14 companies. Current work in progress is aimed to establish a community of practice and develop a National online AI awareness course for Logistics.

CONCLUSION AND FUTURE WORK

8 Conclusion and future work

This chapter concludes this PDEng thesis and presents future work. **Section 8.1** summarizes the main results and findings. **Section 8.2** discusses the results and findings in relation to literature and practice. **Section 8.3** concludes by answering the research questions. **Section 8.4** summarizes the contributions for science and practice. **Section 8.5** indicates limitations of the research results and findings. **Section 8.6** discusses implications of the results and findings. **Section 8.7** concludes by positioning future work. This chapter contains parts of earlier published work.[34]

8.1 Summary of main results and findings

This section summarizes the main results and findings.

Subsection 8.1.1 restates the aims and summarizes the main deliverables
Subsection 8.1.2 highlights the programme of requirements
Subsection 8.1.3 discusses the literature review results
Subsection 8.1.4 summarizes the design methodology
Subsection 8.1.5 accentuates the design and development
Subsection 8.1.6 emphasizes the demonstration and validation

8.1.1 Revisiting the aims and deliverables

Building upon earlier and related work, the aim of the research that resulted in this PDEng thesis was twofold. The first aim was to research, design, develop, test, and implement an industry platform for data-driven logistics, based on the OTM, aimed at the need of SMEs in the logistics industry. Related to industry platform, the second aim was to develop implementation guidelines to support adoption in SMEs. The research projects related to this PDEng thesis resulted in multiple deliverables and follow-up projects. The initial 2-year research project resulted in multiple publications, prototypes, industry testbeds, implementations in 3 organizations, design tools, training materials, and lecture cases. The results are documented in the final project report (Piest and Iacob, 2020) and widely disseminated in both the scientific and industrial community based on the impact plan. Building on earlier and related work, the current research resulted in an industry platform and supporting artefacts to 1) raise awareness about data-driven logistics with inspiring cases, 2) provide re-usable data-driven logistics applications to increase data use in SMEs, and 3) scale up the results via a learning community to increase the competitiveness of the Dutch logistics industry. **Figure 66** presents an overview of the main deliverables that are incorporated in this PDEng thesis.

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[34] This chapter is based on the research paper (Piest et. al., 2021). The results and findings in **Section 8.1** are significantly expanded based on completed research. The subsequent **Sections 8.2 – 8.6** with discussion, contributions, limitations, implications, and future work are fully revised and adapted for this PDEng thesis.

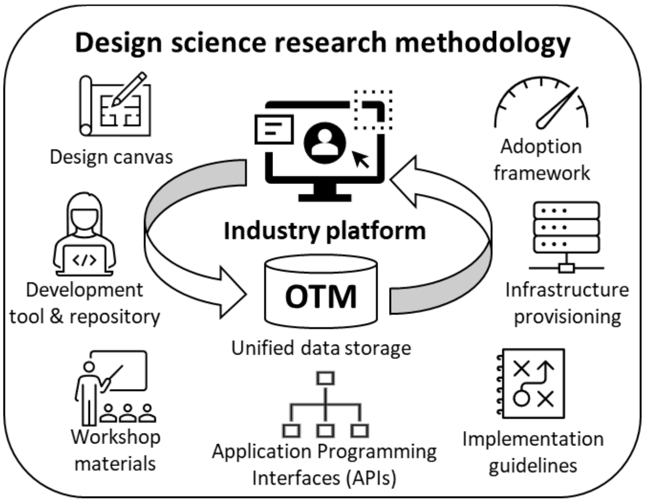

Figure 66: Overview of developed industry platform and supporting artefacts.

The TRL of the industry platform advanced from initial technology concept (level 2) and experimental development (level 3) to actual deployment and validation of the core functionalities and interfaces (level 8) and is currently being implemented in an operational environment at Emons (level 9). The IA design canvas, workshop materials, implementation guidelines, and adoption framework are validated at Emons. The impact plan is utilized to scale up the results and involve a larger group of SMEs. The IA design canvas and workshop materials are implemented and evaluated in 3 design workshops for the logistics industry, involving 25 participants from 14 organizations. This design workshop evolved to a blended workshop design, which is implemented in a LMS to achieve digital enhanced learning. Current work aims to establish a community of practice and develop an online awareness course for the logistics industry to scale up the societal impact.

8.1.2 Programme of requirements

This PDEng thesis outlines the context and programme of requirements for the industry platform for data-driven logistics in SMEs. The main stakeholders have been identified and requirements for the industry platform are gathered and elicited. Realizing the industry platform is a significant software engineering effort and requires involvement of many stakeholders. The established programme of requirements entails 28 requirements. The safety and risk assessment illustrates the various multidisciplinary design aspects, relations between humans interacting with the system, and the relation to the wider environment. The assessment of 15 design aspects emphasizes that the large scale implementation requires incorporation of many other aspects to cover the full lifecycle. Additionally, the ethical assessment adds 7 important requirements to ensure trustworthy AI. Given the limited time span of the PDEng program and related research projects, the focus was on designing and realizing the industry platform and related implementation guidelines for industrial research. However, in addition to assessing the technological feasibility, the broader societal impact is taken into account, and societal embedding of the design is explored by creating future scenarios.

8.1.3 Literature review

Reviewing literature created a theoretical perspective to data use and technology adoption in SMEs. Research about enterprise architecture in SMEs presents both a theoretical and practical approach for SMEs and mapping to the ArchiMate specification. The approach of Bernaert et. al. (2014) is adopted for the design of the industry platform. When it comes to data-driven approaches, there are various options to consider, and many examples exist in literature. The literature review illustrates that data analytics and -mining techniques are widely available, but methods require technical knowledge and are considered too extensive for SMEs. Process mining offers much potential to discover process variations and analyse real-time event data. Looking at more sophisticated data use with AI and RL, various applications are present in literature. Supervised learning and unsupervised ML seem matured, whereas RL is mainly in the status of experimental lab development. Some relevant examples of RL are present but are predominantly used in warehouse context in combination with modern robotics. Current research focuses on combining traditional and modern approaches, for example blending OR approaches such as VRP with RL techniques. Furthermore, FL is considered to be a promising research topic that also connects well with initiatives in the Topsector Logistiek. In addition to the literature review, earlier and related work are summarized and synthesized to form the basis to develop theory ingrained artefacts to support the adoption process and measuring impact. Based on the literature review, a collective approach of Ponis and Christou (2013) is discovered and adopted for this research project to develop the industry platform. Furthermore, an interesting adoption model of Crossland and Smith (2008) is found that provided the foundation to measure operational performance. Together with related work of Gemmink (2019), this offered a starting point for developing implementation guidelines and supporting artefacts.

8.1.4 Design methodology

Based on practice inspired, problem centric research and the literature review, the industry platform and implementation guidelines have been designed, developed, instantiated, demonstrated, and validated using the established DSRM of Peffers et. al. (2007) as the main design methodology. The DSRM was extended with the ADR and systems engineering methods from the PDEng programme. The ADR of Sein et. al. (2011) was incorporated to facilitate stakeholder interaction and formalize the learning and evaluation process. This iterative approach resulted in refinement of industry platform's requirements, functionality, and features, but also fostered the development of additional supporting artefacts and several industry platform improvements. The Agile V-model was adopted to blend in systems engineering approaches from the PDEng program and has proven helpful to utilize the strengths of agile development practices, to facilitate short iterations, while maintaining a systematic and integrated design approach.

8.1.5 Design and development

Based on the design methodology, systems thinking was utilized to conceptualize the industry platform in the context of the logistics industry. The main data sources have been identified and explored using an extended version of the nine-window diagram of Gadd (2011). Lifecycle and time scale thinking have been applied to analyse the OTM. The feasibility of using the OTM for process mining was evaluated based on earlier work and its broader use for analytical purposes has been explored in the current research. This resulted in a various ideas for data-driven logistics applications. Next, the industry platform architecture was modelled using the ArchiMate language and specification. Following, the layered architecture has been decomposed into components and interfaces. Successively, a concrete architecture for the industry platform was modelled in ArchiMate and the OTM was formalized in an ER diagram. The actual development and implementation of the industry platform took place in three iterations by a research, design, and development team. Mock-ups have been created to visualize the industry platform. User stories were created to guide the development process. The results of the research, design, and development efforts demonstrated the technological feasibility of the industry platform. Extending earlier and related work, an IA design canvas, workshop materials, implementation guidelines, and adoption framework were developed to complement the industry platform and measure and monitor benefits realization.

8.1.6 Demonstration and validation

Following the design methodology, an expert panel consultation was used to verify the ideas and concepts of the industry platform. Overall, the experts were positive about the industry platform and collective approach to reach a larger group of SMEs via a learning community. Some doubts and concerns were raised about the current state of OTM adoption and use of the industry platform in small enterprises. The industry platform instantiation displayed the GUI, OTM APIs, OTM database, tool to develop, test, and compare agents, share re-usable agents among SMEs via a repository, and run agents using a supporting infrastructure for provisioning. Industry platform tests showed that the desired functionality satisfies the testing criteria. In addition to testing with practitioners, the platform was tested by potential end-users and the iterations facilitated improvement of the developed functionalities and related artefacts. Case study research at Emons revealed a broad variety of use cases for AI and RL. Here, the IA design canvas, supporting workshop materials, implementation guidelines, and adoption framework were validated. Combining the industry platform and supporting artefacts has proven effective and supported the processes for conducting a pilot and a project to evaluate the potential of AI and RL by developing agents at Emons. The current case study at Emons provides initial support that the use case for smart tendering and refuelling are feasible for RL. Both the pilot and the project illustrated the need to involve different stakeholders and the significant efforts that are required to develop RL agents. The IA design canvas and workshop materials have proven useful to support the ideation and conceptualization process. The pilot and project were used to validate the implementation guidelines and adoption framework to measure and monitor benefits realization. Overall, the pilot and project strengthen the idea that RL, amongst similar and hybrid solution alternatives, is a promising approach to achieve data-driven decision support in logistics. Further empirical research is currently taking place at Emons to implement the dynamic planning and refuelling agent and explore broader use of the industry platform. In addition to case-based research, the impact plan was used to reach a larger group of SMEs with design canvas workshops for the logistics industry, which involved 25 participants on behalf of 14 companies. Building on the results, a blended version of the design workshop was developed and implemented in the LMS of Deltago to facilitate digital enhanced learning. Current work in progress aims to establish a community of practice to provide implementation guidance for 5-10 SMEs and a national online AI awareness course for logistics consisting of 12 modules of each 15 minutes.

8.2 Discussion

This section discusses the results and findings in relation to literature and practice.

Subsection 8.2.1 discusses the results and findings in relation to literature

Subsection 8.2.2 discusses the state of the industry based on empirical research

8.2.1 Reviewing literature

Prior studies have noted the presence of data and potential of AI for the logistics industry. Whereas research regarding (un-)supervised learning seems matured, limited empirical research was found regarding RL approaches to develop data-driven logistics applications. Several studies have shown the potential of RL and identified use cases and scenarios, however most studies have been conducted in (academic) lab environments. Empirical research in logistics and largescale implementations of RL remains scarce in scientific literature. Related work currently focuses on comparing established OR techniques with modern AI, ML, and RL. Most research is based on single-case mechanism experiments. Current research provides some examples of efforts to develop a broader approach, including a RL based decision support system, but to our best knowledge do not address, nor solve, the need for interoperability in the heterogenous logistics business context. More specifically, none of the approaches utilized canonical data models and/or industry standards such as the OTM to develop standardized use cases and re-usable RL agents to foster broader adoption. Earlier work evaluated the use of the OTM for unified storage, integration, interoperability, and querying of logistic event data. Related work indicated the potential of RL and provided a foundation for building knowledge about real-life applications of RL in the logistics industry. In a related research project at Albert Heijn, a RL agent was developed for slotting, and a method for RL-driven business process re-engineering is positioned, which provided interesting insights based on empirical research, concrete examples, tools, and best practices. Although many tasks can be automated, the case study shows that the most challenging remaining parts to automate are assessing the feasibility of RL and selecting the initial RL model and rewards system. This can be addressed by standardizing use cases and providing template agents. However this can lower the efforts to develop RL approaches, it is not expected to eliminate the need for involvement of subject matter experts and might result in performance loss. The case-based research at Albert Heijn illustrated the importance of RL-expertise, domain knowledge, and stakeholder involvement. Based on available literature, earlier and related work, this PDEng thesis and the developed industry platform created a foundation for research about RL in the logistics industry and offers functionality to develop re-usable RL agents for a broad group of SMEs in the logistics industry. Adopting sophisticated data-driven approaches like RL required significant efforts and involvement of highly trained specialists. Adopting RL will most likely be a long-term endeavour for SMEs. While the current research mainly focused on RL, many design and solution alternatives exist, including hybrid approaches, that should be considered. OR methods generally assume a lot of knowledge beforehand about the system parameters, while RL does not or less and learns based on simulation and agent experience. The potential downside of RL is that it does not guarantee the quality of the solution, while ORmethods generally do. For real world problems, a solution is acceptable if produced in a reasonable amount of time. Finding (near) optimal policies using (approximate) dynamic programming is often computationally very intensive and takes time. RL can be faster compared to other approaches, especially in case of large size problems. Nevertheless, none of the discussed approaches are mutually exclusive and comparison studies are required to test which approach works best.

8.2.2 Assessing the state of the industry

There is a significant gap between the state of the art and the state of the industry regarding readiness for data-driven logistics applications, let alone sophisticated RL-approaches. Excel is the main tool for data analytics and SMEs typically lack expertise, tools, and resources to adopt data-driven logistics applications in their daily operations. The developed collective approach can offer a feasible and cost-effective solution alternative to in-house development. The industry platform lowers the initial barriers for SMEs to get started with data-driven logistics. SMEs can especially benefit from the user friendly and non-invasive web-based GUI and utilize the Excel file importer a s steppingstone towards the use of APIs. Creating a separate infrastructure with OTM API endpoints and OTM compliant data storage can be realized in 2 hours. This is a significant reduction of the initial CAPEX to establish the infrastructure for the development of data-driven logistics applications. The repository can further lower the CAPEX by providing pluggable data-driven logistics applications and re-usable agents. This way, the industry platform can develop network effects for a larger group of SMEs. However initial results are promising, the impact and actual benefits that can be realized requires further empirical research and implementation of the industry platform at other SMEs.

8.3 Conclusion

Based on **Section 8.1 and 8.2**, this section concludes by answering the research questions.

Subsection 8.3.1 concludes by answering the main research questions

Subsection 8.3.2 answers the sub research questions

8.3.1 Main research questions

This subsection answers the main research questions presented in **Subsection 1.3.1**.

How can SMEs in the Dutch logistics industry make use of their logistics data and utilize intelligent agents based on the concept of IA to increase their operational and decisional performance?
Industry surveys have shown that Excel is currently the main tool used for data analysis and that organizations make limited use of business reporting software and data science platforms. SMEs, that typically have limited resources and in-house expertise, especially are facing barriers to adopt data-driven approaches in their daily operations. This PDEng thesis introduced a collective approach in the form of an industry platform to develop re-usable data-driven applications for a broad group of SMEs and stimulate adoption via a learning community. The industry platform provides a web-based GUI, enables SMEs to import their data via an Excel importer, and provides a stepping stone towards advanced data analytics based on real-time data exchange with customers, logistics partners, and suppliers. Each SME has its own environment with APIs based on the OTM. The current use of the OTM is enhanced for data analytical purposes. The OTM database offers the foundation to develop and standardize data-driven applications. Based on the collective approach, software developers can create re-usable intelligent agents that SMEs can implement to increase their operational and decisional performance. Literature reviews and empirical research revealed a wide variety of data-driven applications. Case-based research and experimental development provided support for the technological feasibility of the industry platform and initial validation of the results. The supporting design artefacts, including the IA design canvas, implementation guidelines, and adoption framework have proven effective and useful to implement the industry platform.

How can an industry platform and learning community together contribute to increasing the overall competitiveness of the Dutch logistics industry?
SMEs are the backbone of the economy but have limited resources and expertise available to adopt emerging I4.0 technologies. Increasing data use can contribute to the competitiveness of organization. The industry platform and learning community together provide a foundation to develop re-

usable data-driven logistics applications for a larger group of SMEs users. Based on the multi-sided functions of the industry platform, network effects can be realized by software developers when re-usable intelligent agents are made available via the industry platform to multiple SMEs. Organizing the adoption in a learning community can scale up the impact. Because the industry platform is based on the OTM, synergy effects can be realized by connecting to related initiatives of the Topsector Logistiek, including digitalizing the consignment note using the eCMR (via TransFollow), carbon footprinting (via BigMile), and data exchange with the government (as part of DEFLOG). The industry platform can be extended with the iSHARE trust framework to align with the federated data sharing infrastructure that is currently being developed for the Dutch logistics industry and search alignment with IDS developments at European level to sustain a leading position.

8.3.2 Sub research questions

This subsection answers the sub research questions presented in **Subsection 1.3.1** in **Table 2**.

1. **Which data sources, canonical data models and interoperability standards are available for SMEs in the logistics industry?**

There are various data sources available for SMEs in the logistics industry. The industry surveys, summarized in **Subsection 1.1.2**, provided detailed insight into the main information systems used in logistics organizations (e.g., ERP, WMS, TMS, FMS) and heterogenous IT landscape. Excel is the main tool for data analysis and the use of analytical software and middleware is fairly limited. Most data originates from internal data sources. However, data are increasingly exchanged with external parties. Additionally, board computers, IoT devices, and platforms such as MarineTraffic and Flightradar24 can provide real-time data. Open and governmental data sources are available but used to a limited extent. **Subsection 3.1.1** illustrates a common interoperability scenario in logistics and the central role of LSPs. The industry surveys revealed that most data are exchanged via unstructured formats and note the presence of shadow IT to process data from logistics partners, customers, and suppliers. The literature review in **Section 4.5** highlighted interoperability issues and challenges in logistics processes and lack of standardization. Related work based on the OTM showed how certain interoperability issues can be eliminated. Industry surveys illustrated the variety in interoperability standards used, but also a limited adoption of industry standards. GS1 standards for identification of products and locations are used the most. Furthermore, the industry survey indicated limited awareness of Topsector Logistiek initiatives, e.g. OTM and iSHARE. Earlier work, discussed in **Section 4.8**, provided a CLDM to harmonize unstructured data from the internet with industry standards and internal data. The whitepaper of Bastiaansen et. al. (2020) provided an overview of the main standards developed and promoted by SUTC as part of the federated data sharing infrastructure that is being developed for the Dutch logistics industry.

2. **Which schema matchers are capable of automatic mapping and harmonization of logistics data models with internal data models of SMEs?**

In the ALM project, several schema matchers have been studied, a reference architecture is proposed based on machine learning and IA, and a prototype is developed and incorporated in the eMagiz platform as a beta feature. Based on earlier work, discussed in **Section 4.8**, the CLDM is used to test the auto-mapping capabilities with schemas that are used by organizations in the logistics industry. Based on experiments, it is demonstrated that the auto-mapping feature can support integration specialist to create initial mappings between schemas, but the accuracy and precision were insufficient to realize significant productivity gains. The results are published in the project report (Piest and Iacob, 2020), workshop paper (Piest et. al., 2020), and **Appendix C8**. Based on these results and findings, automatic schema matching is not incorporated in the industry platform.

3. **What are typical usage scenarios in which intelligent agents can support SMEs to increase their operational and decisional performance?**

Both the literature review and empirical research revealed a variety of data-driven applications that can support SMEs to increase their operational and decisional performance. Examples from literature regarding the use of intelligent agents are related to dynamic routing, item picking and packing with robots, real-time order dispatching, and inventory management. Much work is based on analytical experiments, simulation, or serious games. Recent studies focus on combining modern and traditional approaches. In the ALM project, the use of intelligent agents was explored in two case studies. At Albert Heijn, a slotting agent has been developed and implemented to support logistics employees to solve the product allocation problem in warehouses. The results and findings have been documented in the project report (Piest and Iacob, 2020) and are included in **Appendix C2-4**. At Kien Logistics Management, a web scraping agent was developed to harvest unstructured data from websites of ocean carriers to track and trace containers in a global forwarding context. The results and findings have been documented in the project report (Piest and Iacob, 2020) and are included in **Appendix C5-7**. Both case studies were based on single-case mechanism experiments. In the ICCOS project, the re-use of intelligent agents was investigated and resulted in the development of the industry platform. Systems thinking in **Section 6.2** resulted in several data-driven logistics applications that can be developed based on the OTM. Based on the systems architecture in **Section 6.3**, four typical agents were ideated, of which two were conceptualized in **Subsection 7.3.4**, to support SMEs with dynamic planning, disruption handling, smart tendering for empty mileage reduction, and condition monitoring and predictive maintenance. Based on a design canvas workshop at Emons, the practical application of intelligent agents was explored and resulted in 49 use cases. First, a pilot was conducted for the experimental development of a RL agent for smart tendering. The results and findings have been published in the research paper (Piest et. al., 2021) and are documented in **Subsection 7.4.2 and 7.4.3**. Next, a project was started to validate the industry platform and develop an agent for dynamic planning and refuelling. This project is currently still in progress. The intermediate results and findings have been documented in **Subsection 7.4.4 and 7.4.5**. The design canvas workshops provided a broader view upon possible data-driven logistics applications based on input of 25 participants from 14 organizations. Thus, there are many opportunities to develop data-driven logistics applications.

4. What are the requirements for the envisioned industry platform and the level of IT knowledge and resources in SMEs?

Realizing the envisioned industry platform, which was first introduced and positioned in the doctoral consortium paper (Piest, 2019), is a significant effort. The program of requirements for the industry platform, which has been published in the research paper (Piest et. al., 2021), entails 28 requirements, which have been described in **Subsection 3.2.4**. The focus of this PDEng thesis is kept on the R&D goals to realize the industry platform for industrial research and experimental development. Societal embedding of the design has been explored but requires further operationalization to cover the full lifecycle and measure the actual value. The wider context has been assessed based on 15 design aspects regarding risk and safety, which have been incorporated in **Appendix E**, and 7 design requirements for trustworthy AI, documented in **Appendix F**. The industry surveys in **Subsection 1.1.2** and the literature review in **Section 4.2** illustrated the level of IT knowledge in SMEs. SMEs typically lack expertise and resources to adopt data-driven logistics approaches. The insights have been incorporated in the industry platform requirements, more specifically in the assumptions in **Subsection 3.2.2**. Based on a collective approach, the industry platform and learning community can offer a cost-effective solution for SMEs and lowers the initial barriers for SMEs. The design rationale is summarized in **Subsection 3.2.3**. However, the experimental development showed that the development of intelligent agents requires significant efforts and involvement of subject matter experts. Moreover, the case studies and related work at Albert Heijn, Kien Logistics Management, and Emons stressed the importance of domain expertise and a multidisciplinary approach.

5. Which adoption strategies, together with the concept of IA, can be applied to increase the usage of logistics data in SMEs?

The literature review regarding technology adoption in SMEs, published in the doctoral consortium paper (Piest, 2019) and discussed in **Section 4.2**, provided both theoretical and practical adoption strategies. The work of Bernaert et. al. (2014; 2016) provided a starting point for designing the industry platform based on the technology adoption model and CHOOSE to align the need of SMEs. Additionally, a collective approach was found and adopted to develop the industry platform. The approach has been described in **Subsection 1.2.2**. More specifically, the industry platform was developed based on the OTM and extended its use and value for data analytics and decision-support. The standardized OTM database provided a foundation for the development of re-usable data-driven applications for SMEs in the logistics industry. The impact plan in **Section 2.6** is developed to foster adoption of the industry platform among a larger group of SMEs in a learning community. **Section 6.5** presented supporting artefacts to stimulate adoption by SMEs, including a design canvas to ideate and conceptualize IA applications, supporting design canvas workshop materials, implementation guidelines, and an adoption framework. The broader use has been explored as part of the DALI learning community and is documented in **Section 7.5**. Towards the future, a data space approach can further stimulate data use by incorporating data from open data providers and governments. Subsequently, alignment with the IDS developments has been explored in the discussion paper (Piest, De Alencar Silva and Bukhsh, 2022).

6. **Which KPIs support measuring the effects of the industry platform on the operational and decisional performance in SMEs and the overall competitiveness?**

The literature review, summarized in **Section 4.7**, offered an extensive knowledge base regarding performance measurement and KPIs. The OTE framework has a good fit with the OTM and the underlying work provided a rich set of KPIs. The report of Cruijssen and ‘t Hooft (2020) provided insight in the indirect and qualitative impact. The program of requirements was extended with a list of candidate KPIs for measuring the effects of the industry platform. As stated earlier, the focus was kept on realizing the R&D goals and requirements for industrial research and experimental development. The instantiated industry platform demonstrated the technological feasibility and the case-based research at Emons provided initial validation of two selected use cases. Although initial results are encouraging, the pilot was not staged to an operational environment and the project is currently in development. Therefore, the actual impact and effects cannot be measured yet. The adoption framework, introduced in **Section 6.5.3**, incorporated several KPIs and has proven helpful to measure and monitor adoption and benefits realization. The results and findings are documented in **Subsection 7.4.3 and 7.4.5**. However the selected adoption model takes the competitive position into account, it primarily focuses on benefits realization in an organization rather than benchmarking the competitive position as part of the market. This remains an open question.

8.4 Contributions

This section summarizes the main contributions of the research.

Subsection 8.4.1 discusses the scientific contributions
Subsection 8.4.2 highlights the contributions for the logistics industry
Subsection 8.4.3 emphasizes the contributions of the research for education
Subsection 8.4.4 discusses contributions to governmental programs

8.4.1 Science

The core contribution of this PDEng thesis is the architecture for an industry platform to deliver data-driven logistics applications that are tailored to the need of SMEs. To our best knowledge no general decision-making platform architecture exists that is based on a collective industry approach and embodies the ideas behind the hybrid intelligence paradigm of IA. The research project and this PDEng thesis contributes to better understanding of the potential use cases for data-driven logistics. The results of experimental development and case-based research at Emons add to the rapidly expanding field of RL. The industry platform provides a rich testbed for further empirical research, experimental development of re-usable agents, and comparison with alternative or hybrid approaches to achieve data-driven logistics in SMEs. This PDEng thesis can be used as a starting point for the research, design, and development of data-driven approaches in logistics. Fellow researchers can benefit from the industry platform and conduct experiments in a space environment and involve industry relations for case-based research.

8.4.2 Industry

This PDEng thesis contains various examples of data-driven logistics applications that can be adopted. The use cases and examples contribute to raising awareness of data-driven logistics applications. The case study at Emons provides in-depth insights in real-life applications and the processes related to the design, development, test, deployment, integration, and implementation in an operational environment. Here, the industry platform is demonstrated in use for a pilot and project. The IA design canvas and supporting workshops have proven effective, useful, and valuable to take the first steps towards data-driven logistics. The implementation guidelines supported the processes to transition ideas into working software in a pilot and project at Emons. The adoption framework supports the measurement and monitoring of benefits realization. This PDEng thesis offers practitioners a starting point and guidance in the form of architecture models, design tools, implementation guidelines, and an adoption framework for data-driven logistics approaches.

8.4.3 Education

The research project resulted in multiple lecture cases, and consortium partners contributed to educational programmes with guest lectures, real-life data sets, and challenges for students. Incorporating the research results in Bachelor and Master courses contributes to professionalization of the educational programmes and provides students a relevant learning environment. The IA design canvas, workshop materials, and blended workshop design can be re-used by educators in courses and projects. Professional trainers can use the IA design canvas and workshop materials to organize workshops within the industry and offer implementation guidance for organizations.

8.4.4 Government

The developed industry platform contributes directly to scaling up the use of the OTM. The experimental use of the OTM for analytical purposes extends the current use for data exchange and value for its users. The realized industry platform demonstrates how the OTM can be used to develop data-driven applications. Several opportunities are identified to connect existing initiatives in the Topsector Logistiek to the industry platform, including iSHARE. Governmental initiatives can be connected to the industry platform, including DEFLOG, as part of the envisioned federated data sharing infrastructure. This way, the industry platform contributes to raising awareness regarding initiatives of the Topsector Logistiek and provides a rich testbed to develop new public data services.

8.5 Limitations

This section indicates the limitations concerning the research, design, and development of the industry platform and impact development.

Subsection 8.5.1 discusses the main limitations from a research perspective
Subsection 8.5.2 emphasizes the limitations of the industry platform
Subsection 8.5.3 highlights limitations regarding impact development
Subsection 8.5.4 stresses limitations concerning the societal embedding

8.5.1 Research

The current research design has several limitations that should be addressed. The PDEng research and this PDEng thesis are mainly focused on technological design and realization of the industry platform and related artefacts for industrial research. However a literature review is conducted to develop theory ingrained artefacts, no strict systematic literature review has taken place. Therefore, the theoretical contribution is limited. Nevertheless, the current research resulted in various contributions and scientific articles. Fundamental research for theory development can take place as part of the PhD research project. Another limitation is that the case study is based on a single-case mechanism experiment and the actual implementation is still in progress. Furthermore, the results of the experimental development as part of the pilot are not compared to solution alternatives. Therefore, the generalizability of the results is limited and requires caution. In spite of its limitations, the research certainly adds to a better understanding of the potential of data-driven logistics applications, especially regarding sophisticated approaches based on AI and RL.

8.5.2 Design and development of the industry platform

The realized industry platform is operational but has several limitations as a result of the design decisions made and selected tools. The industry platform is designed for data-driven logistics applications and the initial version is made available for LSPs. The industry platform is not tested by shippers and transport operators. More general, the application domain of OTM is limited and focuses on operational processes related to the planning and execution of shipments. Related processes such as finance are not supported. Although the core functionality and interfaces are operationalized, the concrete architecture is not fully realized, and a limited set of the program of requirements can be satisfied. The use of iSHARE is foreseen, but not yet implemented. The accounting service is not realized. Furthermore, the current version of the industry platform contains a limited set of tricks and not all agents are realized. The industry platform is developed for industrial research and is currently being implemented in an operational environment. The current process of developing and sharing re-usable agents via the repository is limited to developers.

8.5.3 Impact development

The impact plan has proven helpful to scale up the results of the research project. However the learning community is established, it still is in an early stage of development. Therefore, the broader societal impact is not realized. The 3 design workshops with LCB as part of DALI programme show the potential impact, but significant efforts are needed to adopt data-driven logistics applications in more SMEs. The need for providing implementation guidance is expected to limit scaling up.

8.5.4 Societal embedding of the design

The current industry platform is developed as part of a research project and has limited budget left for further research and development. The societal embedding of the design has not taken place. This limits broader use of the industry platform and full scale implementation because there is uncertainty regarding continuation of the research and development of the industry platform.

8.6 Implications

This section discusses several implications that need to be considered.

Subsection 8.6.1 discusses the implications of the initial results
Subsection 8.6.2 explains the implications related to the choice to use the OTM
Subsection 8.6.3 elaborates the implications related to systems integration
Subsection 8.6.4 highlights the implication related to training and learning
Subsection 8.6.5 concludes with implications regarding strategic commitment

8.6.1 Initial results

The industry platform is established and is currently being implemented at Emons for experimental development and industrial research. Although the industry platform demonstration and validation show promising initial results, the further development of the industry platform will require significant efforts. In order to realize the programme of requirements many other design aspects need to be taken into account to satisfy all requirements. Furthermore, the maintenance and support of the industry platform need to be operationalized for life cycle management.

8.6.2 Use of the OTM

The choice to use the OTM has certain implications that need to be mentioned. The most important implication is that the intended use of the industry platform requires all involved actors to adopt the OTM. Although the adoption of the OTM is progressing, it is not an international industry standard such as GS1. The developers however state that the OTM is interoperable with GS1 standards. The OTM is currently mainly used in the Netherlands for domestic road transport. Moreover, the OTM is focused on operational transport and logistics and does not contain financial processes. The use of the OTM is not formalized or prescribed which implies that there is no unified implementation. Sequence diagrams and choreographies can be developed to address this issue.

8.6.3 Systems integration

In order for the industry platform to function in largescale operational environments as intended, investments in systems integration are required to process large amounts of logistics data and related business transactions. Although the OTM contributes to interoperability of the industry platform, not every TMS or board computer can seamlessly be integrated without involvement of IT specialists or external parties. Establishing systems integrations implies that interoperability can be realized on different levels, including technical, semantic, organizational, and legal.

8.6.4 Training and learning mindset

Although the industry platform provides a user friendly, web-based GUI and supporting training materials and artefacts, some basic training will be required to use the industry platform. In order to get the most benefits from the industry platform and/or start developing data-driven applications, users need to be motivated to learn and invest time and efforts to join the learning community. Alternatively, external assistance can be provided to implement the industry platform.

8.6.5 Strategic, long-term commitment

In the current temporal project environment, the industry platform is developed and used for experimental development and industrial research. Continuing the research and development of the industry platform requires strategic and long-term commitment. The future scenarios that are created for societal embedding of the design point out the implications of discontinuing the research and development, continuing the development as part of research projects, creating a commercial start-up, or starting a non-profit cooperation. Each scenario has its own implications.

8.7 Future work

This section concludes this PDEng thesis by positioning future work.

Subsection 8.7.1 presents the planned development iterations and backlog

Subsection 8.7.2 exhibits planned developments within the learning community

Subsection 8.7.3 positions future scientific and industrial research

8.7.1 Industry platform development

From a software engineering perspective, considerably more work will need to be done to realize additional functionalities, streamline the automation and provisioning of agents, and enabling system administrators and end-users to independently use the platform services. Furthermore, the repository needs to be filled with additional re-usable tricks to increase the value of the industry platform for a larger group of SMEs. Each iteration should also provide room for lifecycle management to keep aligned with OTM developments, solve issues that arise from operational use of the industry platform, and incorporate user input. **Table 23** presents an overview of the planned development iterations and backlog for the industry platform.

Iteration	Functionalities		Features
4		2) OTM API	- Integration with iSHARE authorization registry - Version management: align OTM development
		1) GUI	- Advanced authorizations based on iSHARE - Widget configuration by system administrators - Version management: align OTM development
	OTM	3) OTM Database	- External database access for reporting and BI - Set database authorizations based on iSHARE - Version management: align OTM development
	</>	4) Repository and tool	- Add more agents to the repository: dynamic planning - Set AI authorizations based on iSHARE
		5) Infrastructure provisioning	Automation of resource provisioning
5		6) Accounting service	- Cloud resource consumption tracking - Integration of Kubernetes live log and statistics
		1) GUI	Version management: align OTM development
			System administrator screen:

			- Live log - Statistics
			Workflows and system administrator screens: - Data import (master, transactional, event) - Partner onboarding and third-party access - Selection, training, evaluation of agents - Deployment and monitoring of agents
	</>	4) Repository and tool	Add more agents to repository: predictive maintenance and condition monitoring
		5) Infrastructure provisioning	Resource provisioning by system administrators
	∞	Lifecyle management	- Incorporate OTM developments - User feedback and issues
6		1) GUI	- Dashboard widgets for available agents - Alerts and notifications
		2) OTM API	Endpoints based on GraphQL
	</>	4) Repository and tool	Add more agents to repository: disruption handling
		5) Infrastructure provisioning	Resource optimization by system developers
	∞	Lifecyle management	- Incorporate OTM developments - User feedback and issues
Backlog		1) GUI	- Excel importer: validation and error messages - Automatically find/create entity associations - Azure AD integration
		2) OTM API	Standardized connectors (e.g., TMS, FMS)

	OTM	3) OTM Database	Write access for ETL
	</>	4) Repository and tool	Widget development support and extensions
	🖧	5) Infrastructure provisioning	Resource optimization by system administrators
	💳	6) Accounting service	Electronic invoicing based on usage

Table 23: Overview of planned development iterations and backlog for the industry platform.

Current development work takes place in the ReAL project by the development team and Emons. Several graduate students are developing additional tricks and optimizers based on process mining, BI, (un-)supervised ML, and OR techniques.

8.7.2 Learning community

In addition to the developed implementation guidelines, additional supporting learning materials will be developed as part of the learning community. **Table 24** presents an overview of the planned iterations to develop additional supporting artefacts.

Iteration	Supporting artefacts		Main aim of the artefact
3	📋	Score cards	Supporting researchers, practitioners, and end-users to measure the performance and impact of agents and IA effects.
	💬	eLearning courses for the LMS	Supporting digital enhanced learning with micro lectures and tutorials.
4	</>	Developer guidelines	Supporting developers to create re-usable agents based on specific conventions.
	📖	Developer training materials	Supporting developers to get familiar with the industry platform and learn to apply the developer guidelines.

Table 24: Overview of planned iterations to develop supporting artefacts.

Current educational design and development takes place in the ReAL project by the University of Twente and Deltago in close collaboration with LCB and Port of Twente.

8.7.3 Scientific and industrial research

This PDEng research project mainly focused on industrial research. In the current ReAL project, additional agents are created for experimental development and the industry platform will be implemented at other SMEs. Further experimental development, using a broader range of agents, can shed more light on the feasibility, performance, and impact of identified use cases. Therefore, a broader implementation of the industry platform is planned at Emons. This implementation will also include alternative and hybrid approaches to compare the feasibility, performance, and impact of RL agents with solution alternatives. Additional case study research will be conducted at other SMEs to compare and contrast findings and scale up the use of the industry platform to achieve the broader societal impact. This will also create a testbed to experiment with applications based on FL among SMEs. Future scientific research can focus on comparing traditional and modern approaches, evaluating solution alternatives, and applying hybrid approaches. Furthermore, future scientific research can be done regarding FL and incorporation of data sharing concepts as part of the envisioned federated data sharing infrastructure for the Dutch logistics industry. More specifically, in my PhD research, I will focus on generalizing the results by developing a design theory for IA and methods for measuring IA effects, impact and success.

Declaration

I hereby declare that I have conducted this research and the presented work independently and without the help of others than those indicated. The ideas taken directly or indirectly from external sources are made recognizable as such in the acknowledgement and referencing throughout this PDEng thesis. I respect the code of conduct for scientific integrity and applied its guiding principles to the best of my knowledge. Several measures are undertaken. As stated in the beginning of each chapter, this work is a synthesis and significant extension of earlier published and presented scientific papers. Each chapter starts with references to (parts of) the published works and explanation how the work is extended/enhanced. Images, models, and tables are updated and adjusted for use in the PDEng thesis. Significantly more background materials and additional results are incorporated. Completed future work and reviewer's comments are processed. Taken together, this PDEng thesis delivers significantly more results and findings than the individually published articles.

Piest

Jean Paul Sebastian Piest

Postface

This PDEng thesis concludes my PDEng journey, but it also marks the start of my academic career. Parallel to the PDEng, my research resulted in several academic publications which are presented during international conferences and workshops (**Appendix A**). The results are documented in the final project report (Piest and Iacob, 2020), presented during the annual congress of the Topsector Logistiek, and got featured in the media several times which let knowledge flow.

Throughout the PDEng, I have kept close connections with the industry and utilized my network as a catalyst for action design research. This enabled me to expand the visibility and impact of my research and scale up results obtained from case-based research by collaborating with branch organizations. Moreover, this enabled me to form research consortia and acquire funding to continue the research in pursue of my PhD. Looking back, my decision to go for a PDEng turned out to deliver a true industrial PhD.

“You should see a university as a business. It is not the intention to make a profit, but it is about the characteristics of a company: everyone focused on the same goal; a decentralized organization; willingness to take risks; not being afraid to do new things; market-oriented thinking.”

Prof. Dr. Ir. H.H. van den Kroonenberg – Translated from the Volkskrant, 1985

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Organization	Involved	Contribution
Albert Heijn	Pieter Meints	Providing industry cases for research, supervision of students, and attending consortium meetings.
	Arjan de Vos	Co-supervision of students and attending consortium meetings.
	Benno Jaspers	Supporting and facilitating the research.
ABC Flows	Christa Baas	Providing industry cases for research and attending consortium meetings.
Bullit Digital	Martijn Gemmink	MSc graduate at Albert Heijn, part of the core research team, development of the front-end application, OTM database and API, co-author, participation in workshop, development of agents, attending consortium meetings, and supporting dissemination of results.

	Bjorn Goossens	Part of the core research team, development of the infrastructure and provisioning, co-author, participation in workshop, attending consortium meetings, and supporting dissemination of results.
Breda University of Applied Sciences	Bas Groot	Organizing the design canvas workshops for the LCB / DALI community, offering the possibility to validate the IA design canvas and developed training materials.
CAPE Groep	Maik Wesselink	Providing industry cases for research, supervision of students, and attending consortium meetings.
	Gilang Charismadiptya	Co-author and MSc graduate at CAPE Groep.
	Johan Buis	Co-author and MSc graduate at CAPE Groep.
	Lucas Meertens	Co-author and supervision of students.
	Samet Kaya	Supervision of students.
	Rob ter Brugge	Supporting and facilitating the research.
Deltago	Marcel Wouterse	Providing industry cases for research, validation of platform and requirements, planning and execution of the design workshop, pilot, and project at Emons, proof reading of the PDEng thesis manuscript, supervision of students, attending consortium meetings, and supporting dissemination of the results.
TKI DINALOG	Simone van der Velden	Supporting dissemination of the results among the logistics community via the website of TKI DINALOG and organization of events.
	Liesbeth Brügemann	Organizing the AI roundtable and supporting dissemination of the results among the logistics community.
	Bas van Bree	Supporting dissemination of the results among the logistics community.
Districon	Wouter Nering Bogel	Providing industry cases and attending consortium meetings.

	Niels Veenman	Validation of the platform and requirements, supervision of students, and attending consortium meetings.
	Victor Ponsioen	Supervision of students and attending consortium meetings.
	Jack Pool	Supporting and facilitating the research.
Emons	Gerard Alders	Providing industry cases for research, validation of platform and requirements, participation in workshop, supervision of students, attending consortium meetings, and support dissemination of the results.
	Thomas Massop	Participation in workshop, validation of platform and requirements, and supervision of students.
	Kevin Lemmens	Validation of platform and requirements, testing, and validation of the platform functionality.
	Saumyajit Parida	Validation of platform and requirements, testing, and validation of the platform functionality.
	Oliwia Orcholska	Supporting dissemination of the results.
	Nathalie Emons-Gerrits	Supporting dissemination of the results.
	Marjolein Emons-Colijn	Supporting dissemination of the results.
	Daan Emons	Supporting and facilitating the research and attending consortium meetings.
Evofenedex	Lotte Baak-van Kleunen	Facilitating requirements gathering, provide insight in industry surveys, organization of events, and supporting dissemination of the results.
	Stefan Heeringa	Facilitating requirements gathering, member of the expert panel, co-develop questions for the industry survey, providing assignments for graduate students, and supporting dissemination of the results.
	Guus Peters	Supporting dissemination of the results.
	Nanne Schriek	Supporting and facilitating the research.
	Johan Kerver	Supporting and facilitating the research.

Kien Logistics Management	Michiel Brokke	Providing industry cases for research, supervision of students, attending consortium meetings and supporting dissemination of the results.
	Michael van Steen	Supporting dissemination of the results.
	Frans Denie	Supporting and facilitating the research.
King Nederland	Arthur van Heerik	Providing industry cases for research.
	Stephan Rieff	Supervision of students.
	Rogier Sneep	Supporting and facilitating the research.
Lambooij Logistiek	Menno Lambooij	Member of the expert panel.
Logistiek.nl	Heres Stad	Supporting dissemination of the results.
LOGAPS	Ronald Schepers	Providing industry cases for research and supporting dissemination of the results.
	Jaap Roorda	Providing industry cases for research and supporting dissemination of the results.
LUVANE	Luuk van Ewijk	Cartoonist and supporting dissemination of results.
Niké Creatief	Niké Schuurmans	UI/UX designer for the platform.
Port of Twente	André Pluimers	Providing industry cases for research and supporting dissemination of the results.
Sjusjun	Corona Zschüsschen	Logo designer for the platform and illustrator for the PDEng thesis cover.
TLN	Wout van den Heuvel	Member of the expert panel and supporting dissemination of the results.
TNO	Harrie Bastiaansen	Editor and co-author, supervision of students, and supporting dissemination of the results.
Topsector Logistiek	Yolande de Heus	Supporting dissemination of the results.
Veenman	Arjan Karssen	Providing industry cases for research, supervision of students, attending consortium meetings, and supporting dissemination of the results.
	Hanneke Mulder	Providing industry cases for research, supervision of students, attending consortium meetings, and supporting dissemination of the results.

Vereniging Logistiek Management	Jolanda Bakker	Facilitating requirements gathering, organization of events, and supporting dissemination of the results.
	Evelyn Mynott	Facilitating requirements gathering, organization of events, and supporting dissemination of the results.
	Judith de Witte	Organization of events and supporting dissemination of the results.
University of Twente	Maria Eugenia Iacob	Project manager, main applicant of ALM, ICCOS and ReAL, part of the core research team, PDEng thesis and daily supervisor, co-author, proof reading of the PDEng manuscript, supervision of students, attending consortium meetings, and supporting dissemination of the results.
	Jos van Hillegersberg	Co-supervisor, proof reading of the PDEng manuscript, and supporting dissemination of the results.
	Marten van Sinderen	Main applicant of CLiCKS, part of the core research team, co-author, attending consortium meetings and supervision of students.
	Rob Bemthuis	Co-author and supporting dissemination of the research.
	Jennifer Cutinha	Co-author and BSc graduate at Emons.
	Faiza Bukhsh	Co-author and supervision of graduate student.
	Patricio De Alencar Silva	Co-author and part of the CLiCKS project team.
	Martijn Mes	Supervision of graduate student.
	Martijn Koot	Supervision of graduate student.
	Wieger Kloppenburg	MSc graduate at Albert Heijn.
	Wim Klaassen	BSc graduate at CAPE Groep.
	Nina Bussmann	MSc graduate at CAPE Groep.
	Tom Boerrigter	MSc graduate at CAPE Groep.
	Ewout Gort	MSc graduate at Emons.
	Maryam Azani	MSc graduate at Emons.
	Robbin Vording	BSc graduate at Emons.

	Remco Overvelde	BSc graduate at Evofenedex.
	Bozhidar Velinov	BSc graduate at Evofenedex.
	Daniel van der Werf	BSc graduate at Evofenedex.
	Anne Kusters	BSc graduate at Evofenedex.
	Simona Búranová	BSc graduate at Emons.
	Thom Baas	BSc graduate at Emons.
	Novianita Isnaynizahra	BSc graduate at Emons.
	Beloslava Petkova	BSc graduate at Emons.
	Bhinawa Putra Raja	BSc graduate at Emons.

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Piest, J.P.S., & Iacob, M.E. (2020). Publieke eindrapportage: Autonomous Logistics Miners for Small and Medium-sized Businesses. TKI DINALOG. Available online: https://www.dinalog.nl/wp-content/uploads/2020/10/TKI-DINALOG-Publieke-eindrapportage-ALMSMB.pdf.

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Appendices

A. Related publications

This appendix contains an overview of related scientific papers, industry reports, and media items.

Scientific papers directly related to this PDEng thesis

Piest, J.P.S. (2019). "A Platform Architecture for Industry 4.0 Driven Intelligence Amplification in Logistics," 2019 IEEE 23rd International Enterprise Distributed Object Computing Workshop (EDOCW), 2019, pp. 174-178, DOI: https://doi.org/10.1109/EDOCW.2019.00038.

Piest, J.P.S., Iacob, M.E., & van Sinderen, M.J. (2020). A federated interoperability approach for data driven logistic support in SMEs. In M. Zelm, B. Young, G. Doumeingts, H. Karray, & L. Elmhadbhi (Eds.), 10th International Conference on Interoperability for Enterprise Systems and Applications, I-ESA 2020 (CEUR Workshop Proceedings; Vol. 2900). CEUR. http://ceur-ws.org/Vol-2900/ DOI: http://ceur-ws.org/Vol-2900/WS2Paper1.pdf.

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Piest, J.P.S., Cutinha, J.A., Bemthuis, R. & Bukhsh, F.A. (2021) Evaluating the Use of the Open Trip Model for Process Mining: An Informal Conceptual Mapping Study in Logistics. In Proceedings of the 23rd International Conference on Enterprise Information Systems (ICEIS 2021) - Volume 1, pages 290-296 DOI: https://doi.org/10.5220/0010477702900296. ISBN: 978-989-758-509-8.

Piest, J.P.S., Iacob, M.E., van Sinderen, M.J., Gemmink, M. & Goossens, B. (2021) "A Reinforcement Learning Platform for Small and Medium-sized Enterprises in Logistics," 2021 IEEE 25th International Enterprise Distributed Object Computing Workshop (EDOCW), 2021, pp. 289-298, DOI: https://doi.org/10.1109/EDOCW52865.2021.00060.

Piest, J.P.S., De Alencar Silva, P., & Bukhsh, F.A. (2022). Aligning Dutch logistics data spaces initiatives to the international data spaces: Discussing the state of development. In press: 11th International Conference on Interoperability for Enterprise Systems and Applications, I-ESA 2022 (CEUR Workshop Proceedings).

Piest, J.P.S., Iacob, M.E., & Wouterse, M.J.T. Designing intelligence amplification: a design canvas for practitioners. In review: 8th International Conference on Human Interaction & Emerging Technologies.

Scientific papers related to the research project

Iacob, M.E., Charismadiptya, G., & Sinderen, M.J., and Piest, J.P.S. (2019). "An Architecture for Situation-Aware Smart Logistics," 2019 IEEE 23rd International Enterprise Distributed Object Computing Workshop (EDOCW), 2019, pp. 108-117, DOI: https://doi.org/10.1109/EDOCW.2019.00030.

Piest, J.P.S., Bemthuis, R.H., & Charismadiptya, G. (2020). "Demonstrating the Architecture for Situation-aware Logistics using Smart Returnable Assets," 2020 IEEE 24th International Enterprise Distributed Object Computing Workshop (EDOCW), 2020, pp. 86-90, DOI: https://doi.org/10.1109/EDOCW49879.2020.00024.

Industry reports

Piest, J.P.S., & Iacob, M.E. (2020). Publieke eindrapportage: Autonomous Logistics Miners for Small and Medium-sized Businesses. TKI DINALOG. Available online: https://www.dinalog.nl/wp-content/uploads/2020/10/TKI-DINALOG-Publieke-eindrapportage-ALMSMB.pdf.

Bastiaansen, H.J.M., Nieuwenhuis, C.H.M., Zomer, G., Piest, J.P.S., van Sinderen, M.J., Dalmolen, S., & Hofman, W. J. (2020). The logistics data sharing infrastructure. August 2020. TKI DINALOG. Available online: https://www.dinalog.nl/wp-content/uploads/2020/08/Dinalog_Whitepaper-Data-Infrastructure_DEF.pdf.

Cruijssen, F. & ’t Hooft, D. (2020). Inventarisatie praktijkimpact 4C. TKI DINALOG. Available online: https://www.dinalog.nl/wp-content/uploads/2020/12/Dinalog_Rapport-Use-Cases_DEF.pdf.

Media coverage

Kunstmatige intelligentie en logistiek - Evofenedex Magazine (11-10-2018)
Opkomst kunstmatige intelligentie: verschuiving in mindset en focus nodig - Logisticx (11-2018)
Summit ketenregie: data delen alleen is niet de oplossing - Logistiek.nl (16-12-2018)
Systemen sturen de keten de goede kant op - Online magazine ketensamenwerking (27-01-2019)

Logistics Miners for SMEs – Resultatenboek Topsector Logistiek (16-04-2019)

Smart data mining agents helpen mkb bij datagedreven beslissingen – Dinalog.nl (09-09-2020)

Special Hightech Business & Entrepreneurship – U-Today, p. 20-21 (06-01-2020)

Intelligent agent to support logistics – UT Strategic Business Development & Luvane (13-07-2020)

AI is echt niet alleen voor data scientists – Logistiek.nl (20-10-2020)

De impact van 4C in de praktijk - Dinalog.nl (03-12-2020)

Onderzoeksresultaten delen met geïllustreerde posters – Dinalog.nl (09-06-2021)

Emons: Lege kilometer besparen met Artificiële Intelligentie - NL AI Coalitie (31-08-2021)

Jury maakt genomineerden Dutch BI & Data Science Award 2021 bekend - Passioned (13-09-2021)

B. Data management plan

This template is intended for creating a data management plan, based on the data management section that was part of your research proposal. NWO expects you to incorporate any comments received from the referees and/or the committee about the data management section in this data management plan.

What does NWO understand as research data?

Research data are the evidence that underpin the answer to research questions and can be used to validate findings. Data can be quantitative information or qualitative statements collected by researchers in the course of their work by experimentation, observation, modelling, interview or other methods, or information derived from existing evidence.

For the purpose of NWO's data management policy, the definition of research data does not include physical objects such as scientific and archaeological collections, physical arts works or biobanks; however, digital information extracted from such objects are to be regarded as research data.

Software is also not included in the definition. NWO recognizes that software (algorithms, scripts and code developed by researchers in the course of their work) may be necessary to access and interpret data. In such cases, the data management plan will be expected to address how information about such items will be made available.

About this template and how to proceed

This template is in line with Science Europe's "Core Requirements for Data Management Plans".

You are kindly requested to complete the plan below and submit it to NWO within four months after the awarding of the grant. NWO will review the data management plan as quickly as possible. If necessary, NWO will call upon the help of (data) experts from your scientific discipline for the evaluation. As soon as the data management plan has been approved by NWO, the project can be started. It is advised to regularly review the data management plan when required during the course of the research project.

You are expected to consult with research data management support staff at your home institution for the completion of this plan[35]. NWO strongly advises researchers to seek such support at an early stage. Plans that have not been consulted with institutional data management support staff will not be accepted.

You should submit the completed form via the online application system ISAAC. The main applicant has to submit the data management plan via his/her/their own ISAAC account. Data management plans not submitted via ISAAC will not be taken into consideration. The plan can be completed in Dutch.

We strongly advise you to complete this plan through DMP-online, a web-based tool created by the Digital Curation Centre that helps to create, review, and share data management plans that meet institutional and funder requirements. DMP-online makes it easy to share the plan with institutional data management support staff for comments and advice. Some Dutch universities have institutional instances of the tool that allow you to sign in with your institutional credentials. Through the tool, you will benefit from additional guidance and explanations. A PDF of the plan can be downloaded at the end for submission into ISAAC.

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[35] All universities and university medical centres provide professionalised support for research data management through their university library or ICT-department. A list of contact persons can be found on the website of NWO.

0	**General Information**	
0.1	Name applicant and project number	Prof.dr. M.E. Iacob, project nr. 439.20.613
0.2	Name of data management support staff consulted during the preparation of this plan	Dr. Q. ZHANG (QIAN) Research Data Steward, Faculty of Behavioural, Management and Social sciences (BMS), University of Twente
0.3	Changes on sections 2.1, 3.1, etc.	From meeting with Dr. Qian Zhang.

1	**What data will be collected or produced, and what existing data will be re-used?**	
1.1	Will you re-use existing data for this research?	☐ Yes ☒ No
	If yes: explain which existing data you will re-use and under which terms of use.	NWO encourages the re-use of existing data wherever possible. Explain which existing data you will re-use and state any constraints on re-use of existing data if there are any.
1.2	If new data will be produced: describe the data you expect your research will generate and the format and volumes to be collected or produced.	- We will collect qualitative data regarding goals, problems, and requirements from stakeholders, after informed consent, using semi-structured interviews and questionnaires. Raw and processed data will be stored in PDF format. Expected volume < 1 GB. - We will develop/define (meta)data schemas for data that stakeholders want to use as training and test data in our platform. These schemas will be stored in PDF and/or RDF format. Expected volume < 1 GB. - We will collect data on logistics process execution behaviour from data loggers in the data management component of the platform. The data will be stored in RDF format. Expected volume <10 GB. - We will also ask stakeholders to supply real (past) order execution data, or we generate synthetic input data for the training and testing of the AI component of the platform. Input data will be stored in RDF format. Output data generated by the simulator regarding data exchange/sharing behaviour will be stored in PDF, XLS and/or RDF format. Expected volume < 10 GB. - We will develop an architecture and prototype of the platform system supporting data collection/exchange/sharing in logistic networks.
1.3	How much data storage will your project require in total?	☐ 0 – 10 GB ☒ 10 – 100 GB ☐100 – 1000 GB ☐ >1000 GB

2	What metadata and documentation will accompany the data?	
2.1	Indicate what documentation will accompany the data.	The documentation accompanying this data corresponds with defined deliverables in the project work plan, as follows: - Qualitative data regarding goals, problems, and requirements from stakeholders: covered by D1.1: report on the classification and description of requirements based on interviews with consortium partners, stakeholders and literature. - (Meta)data schemas: covered by D2.1: Version 1.0 of the platform covering: Front-end application: user management, API keys; Data collection and preparation; Data analysis and pre-processing; ETL process for file import; Real-time data exchange using OTM. - Data collected on logistics process execution behaviour from data loggers in the data management component of the platform. covered by D2.1: Version 1.0 of the platform covering: Front-end application: user management, API keys; Data collection and preparation; Data analysis and pre-processing; ETL process for file import; Real-time data exchange using OTM. - Input real (past) order execution data or synthetic input data for the training and testing of the AI component of the platform: covered by D2.2: Version 2.0 of the platform covering: Creating the environment, the model and the reward system, Train and test multiple RL algorithms, perform (hyper)parameter tuning, Deploy the agent, Evaluate performance of the agent. - Prototype: D2.3: Version 3.0 of the platform. This documentation will help other people to reproduce the activities performed within the project, describing the data collected and their associated metadata with support of the knowledge on existing standards, e.g., Open Trip Model (OTM). The documentation and the datasets will be linked through persistent identifiers, and the consortium will decide whether they will be stored together during the project.
2.2	Indicate which metadata will be provided to help others identify and discover the data.	We will follow W3C PROV to express provenance of our data, OTM to format logistics data, and Dublin Core metadata to allow interoperability and use of our data by others.

3	How will data and metadata be stored and backed up during the research?	
3.1	Describe where the data and metadata will be stored and backed up during the project.	☒ Institution networked research storage ☐ Other (please specify)

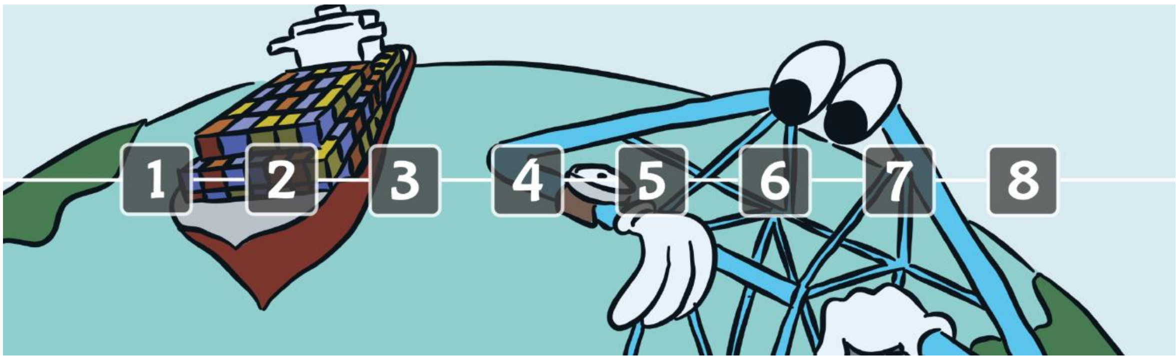
	Explanation:	We will use network storage of the University of Twente, e.g., offered through the BMS Lab (https://bmslab.utwente.nl/data-management-and-policies/), which provides regular backups and cover required data policies, including GDPR. The consortium will decide during the project whether dynamic data will also be stored and shared through DANS/Dataverse.nl.
3.2	How will data security and protection of sensitive data be taken care of during the research?	☐ Not applicable (no sensitive data) ☒ Default security measures of the institution networked research storage ☐ Additional security measures (please specify)
	Explanation:	Our data are not expected to be very 'sensitive'. Most 'sensitive' is the data that is collected with data loggers/connectors when our system is used in validation experiments with actual end-users, and the data that is produced by analytical functions with input data from actual end-users. End-users in this case are actors in a logistics network (e.g., shipper, logistic service provider, third-party carrier). For storage and management of data, we will use networked storage of the University of Twente where data are regularly backed up at the university data centres. For this, the BMS Lab data management policy (https://bmslab.utwente.nl/wp-content/uploads/2017/03/Advice-Faculty-Datapolicy-BMS_2016_2017online.pdf) will apply, in addition to the general information security policy at the University of Twente (https://www.utwente.nl/en/lisa/University-information-management/informationsecurity/).
4	**How will you handle issues regarding the processing of personal information and intellectual property rights and ownership?**	
4.1	Will you process and/or store personal data during your project?	☒ Yes ☐ No
	If yes, how will compliance with legislation and (institutional) regulation on personal data be ensured?	The data described in 2.1 above will only include personal data about the stakeholders participating in the requirements analysis (D1.1) and implementation (D3.1, D3.2, D3.3). Only the name of the stakeholders will be stored with pseudonymization (artificial identifiers) algorithm that is already part of the University of Twente data competency centre guidelines, which address GDPR. Both names and artificial identifiers will be published with highest accessibility restrictions for only consortium partners that require the information. Express consent will be used to address the privacy of the stakeholders via University of Twente form templates.
4.2	How will ownership of the data and intellectual property rights to the data be managed?	This is covered in the Consortium Agreement as follows: - Each project partner will own the results it generates including all IPR on such results.

		- All project partners that do not own the IPRs on particular results, will have the irrevocable, worldwide, perpetual, royalty free, non-transferable license, without the right to sublicense, to use those results for internal research purposes, excluding contract research but including research in national and EU-funded subsidy projects, and educational purposes.
5	**How and when will data be shared and preserved for the long-term?**	
5.1	How will data be selected for long-term preservation?	☒ All data resulting from the project will be preserved for at least 10 years ☐ Other (please specify)
	Explanation	We do not foresee that any exceptions on long-term (at least 10 years) preservation of the data that is collected or generated by the project.
5.2	Are there any (legal, IP, privacy related, security related) reasons to restrict access to the data once made publicly available, to limit which data will be made publicly available, or to not make part of the data publicly available?	☒ Yes ☐ No The data that is sensitive to one or more of the project partners, particularly the private companies, will not be published openly. These data will remain in the organization responsible for producing the data. The main reason is that these data might embed important information about the business models of the private companies in the consortium, which may compromise their business activities and position within the market.
5.3	What data will be made available for re-use?	☐ All data resulting from the project will be made available ☒ Other (please specify)
	Explanation	All data produced by the project, of the categories described in 2.1 above, will be made available for re-use, except the data that is sensitive to one or more of the project partners. In the latter case, the data will be generalized or limited in such a way as not to reveal any specifics of the concerned partners.
5.4	When will the data be available for re-use, and for how long will the data be available?	☒ Data available as soon as article is published ☒ Data available upon completion of the project ☐ Data available after completion of project (with embargo)
	Explanation	Data underpinning research papers are made available to other researchers at the time of publication. Other data, of the categories

		indicated in 2.1 above, are made available upon completion of the project. No exclusive use of the data will be claimed. As described in the Consortium Agreement, all intended publications will be previously submitted for approval to the project partners, and partners have two weeks to indicate whether they agree or not. In case a partner does not agree with the intended publication, the partner can postpone the publication for a period of maximally three months and/or request deletion of any of its confidential information. This procedure also applies to underpinning data or any other data that is intended to be made available.
5.5	In which repository will the data be archived and made available for re-use, and under which license?	At the end of the project, the data will be permanently archived in 4TU.ResearchData, receiving the appropriate persistent identifiers. The archiving will be done in such a way, with appropriate metadata, that it remains accessible and available for re-use. This will be done under the standard license for data availability (CC0 or CC-BY).
5.6	Describe your strategy for publishing the analysis software that will be generated in this project.	We will produce data using open standards that will not require specific analysis software.

6	**Data management costs**	
6.1	What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?	We do not expect a high amount of data to be stored and therefore no substantial costs to be made. Any costs will be covered by the involved UT groups. Amount of time for data management is estimated as 1hr/wk. The repository we are going to use (4TU.RD) is free of charge for data under 1 TB per year per UT researcher, therefore, we do not expect any costs for making the data available and re-usable to others.

C. Illustrated research posters



The past two years, I've had the opportunity to be part of a multidisciplinary consortium and conduct scientific, industrial and experimental research regarding artificial intelligence and intelligence amplification in the logistics industry as part of the **TKI DINALOG project Autonomous Logistics Miners for Small and Medium-sized Businesses**.

Action design research in Logistics

Together with involved consortium partners, students, and fellow researchers, we have completed multiple projects using action design research and presented the results during conferences, workshops and seminars. The projects and interaction with people from different disciplines created a challenging learning environment. The industry testbeds at **Albert Heijn** and **Kien Logistics Management** with **CAPE Groep** facilitated rapid prototyping and software development. Together with **Deltago**, we've conducted case study research and studied the development of intelligence amplification applications from multiple perspectives. Inspired by **Alexander Osterwalder**, we developed a design canvas to ideate and conceptualize intelligence amplification applications. The results are documented in the **final project report** which we presented during the **annual congress** of the Topsector Logistiek. Currently, I'm writing a book about *Designing intelligence amplification* and completing the **Professional Doctorate in Engineering** program at the University of Twente.

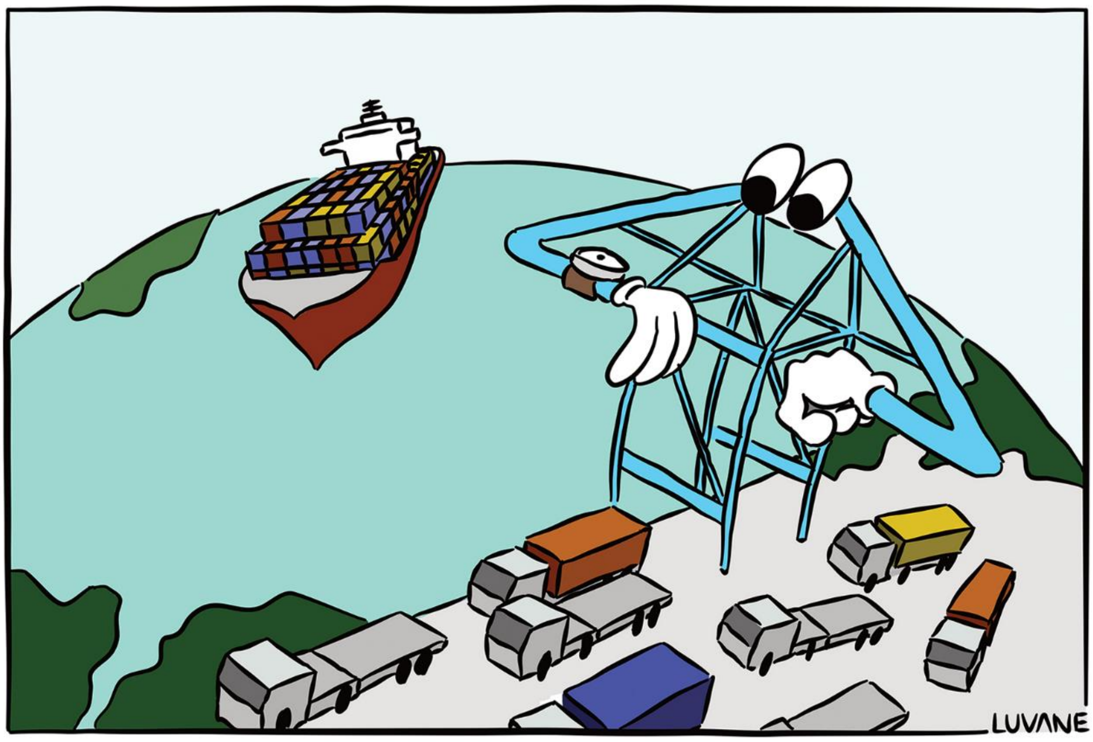
From research poster to conversation piece

Inspired by **Harry van den Kroonenberg**, former professor, rector magnificus and ideator of the "entrepreneurial university", I consider valorisation to be an important and integral aspect of my work as a researcher. Next to incorporating research results and cases in educational programs, I thought about alternative ways to share the results and increase the impact, because *"Knowledge must flow" Harry van den Kroonenberg.*

Following up on the **series of research posters about UT research projects** that were created for last year's edition of Create Tomorrow, I teamed up with cartoonist **LUVANE** to create a series of illustrated posters for the TKI DINALOG project. Not solely for sharing research results, but for a number of reasons and (interrelated) goals which I will list and briefly explain below.

The illustrated posters:

1. are a *thank you* for the involved consortium partners, researchers and students, and *acknowledgement of their valuable contributions* to the project.
2. help us *share the research outcomes,* including related theses and/or publications, with a broader audience to "*let knowledge flow*".
3. incorporate different use cases to *demonstrate the diversity of applications* and to inspire you to *start exploring* intelligence amplification applications yourself.
4. are designed to *spark debate* about intelligence amplification and *connect* involved consortium partners to people that are interested in the research and/or case studies.
5. will, together with the feedback and involvement, support us to *continue research* regarding intelligence amplification applications and *develop a tailored online course*.



Considerations behind the poster design - by LUVANE

The strength of the upcoming series of posters lies in the ability to grab the attention of a wide audience through their ‘friendly’ and humorous character, therewith becoming a conversation piece for various target groups. An example of this is the previously published research poster **Intelligent agent to improve logistics**.

The sole function of the illustrations is to create a pleasant connection with the potential reader, while communicating the broader context of the research poster (e.g., ‘something logistics related’ or ‘delivery of packages’). A dialogue or caption would attract too much attention to certain words or topics, whereas an infographic with textual elements would lack the humour and accessibility of a ‘gag cartoon’. On top, illustrations without text are ideal for usage among various social media platforms and professional networks.

Regarding the text, the deliberate choice was made to use the full field specific vocabulary. This is to ensure that professionals in the field know exactly what the research is about. To allow those who do not fully understand the content to find out more about it, there is an elaborate section with background information on each poster. This way readers can easily contact the involved researchers, visit the website of the TKI DINALOG project or read the academic publication linked to the poster.

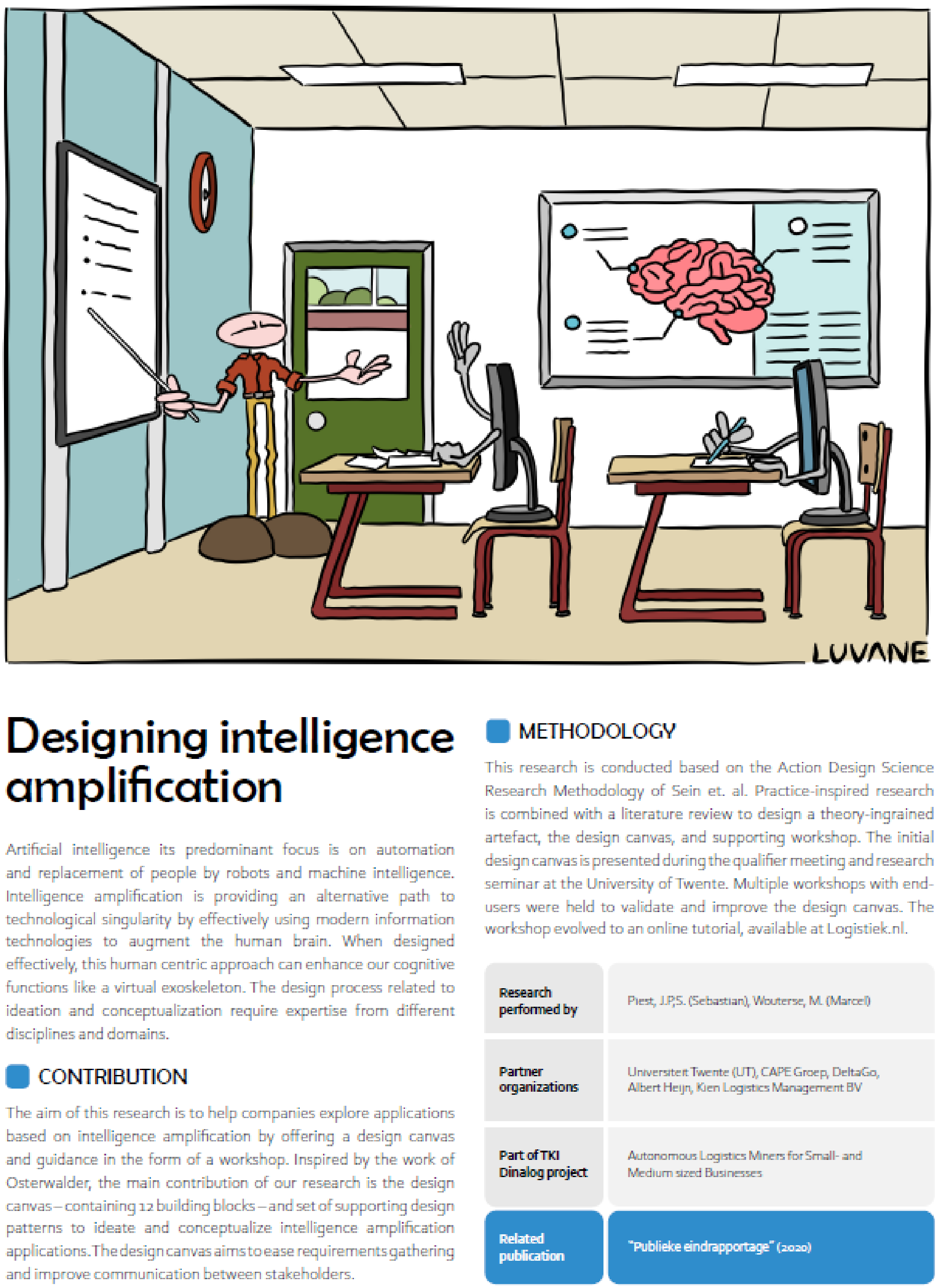
Weekly coffee conversations

In the upcoming weeks, we will share and discuss a series of eight illustrated posters related to the project. Each Tuesday around coffee time (10 AM CE(S)T) an illustrated poster will be introduced via a LinkedIn article and made available via our **project page on ResearchGate**. Here you can also access the research poster **Intelligent agent to improve logistics**.

The articles will be listed here so you can easily browse, and access illustrated posters:

1. **Designing intelligence amplification**
2. **Solving slotting puzzles with agents**
3. **Data validation with rule-based machine learning**
4. **Adoption model for reinforcement learning**
5. **The journey towards control tower 4.0**
6. **Ocean carrier KPI dashboard**
7. **Predicting container vessel arrival times**
8. **Automatic mapping of logistics data**

C.1. Designing intelligence amplification



Designing intelligence amplification

Artificial intelligence its predominant focus is on automation and replacement of people by robots and machine intelligence. Intelligence amplification is providing an alternative path to technological singularity by effectively using modern information technologies to augment the human brain. When designed effectively, this human centric approach can enhance our cognitive functions like a virtual exoskeleton. The design process related to ideation and conceptualization require expertise from different disciplines and domains.

CONTRIBUTION

The aim of this research is to help companies explore applications based on intelligence amplification by offering a design canvas and guidance in the form of a workshop. Inspired by the work of Osterwalder, the main contribution of our research is the design canvas – containing 12 building blocks – and set of supporting design patterns to ideate and conceptualize intelligence amplification applications. The design canvas aims to ease requirements gathering and improve communication between stakeholders.

METHODOLOGY

This research is conducted based on the Action Design Science Research Methodology of Sein et. al. Practice-inspired research is combined with a literature review to design a theory-ingrained artefact, the design canvas, and supporting workshop. The initial design canvas is presented during the qualifier meeting and research seminar at the University of Twente. Multiple workshops with end-users were held to validate and improve the design canvas. The workshop evolved to an online tutorial, available at Logistiek.nl.

Research performed by	Piest, J.P.S. (Sebastian), Wouterse, M. (Marcel)
Partner organizations	Universiteit Twente (UT), CAPE Groep, DeltaGo, Albert Heijn, Kien Logistics Management BV
Part of TKI Dinalog project	Autonomous Logistics Miners for Small- and Medium sized Businesses
Related publication	"Publieke eindrapportage" (2020)

C.2. Solving slotting puzzles with agents

Solving slotting puzzles with agents

Albert Heijn has internally developed an application to support the slotting process in the various distribution centers. Slotting is a dynamic process in which new products, e.g., promotions or seasonal products, are assigned to specific locations based on product characteristics, store demand forecasts, and a set of rules and procedures. As the assortment is changing over time, storage space is limited, products have different characteristics and demand patterns, the slotting puzzle is constantly changing and therefore difficult to automate.

CONTRIBUTION

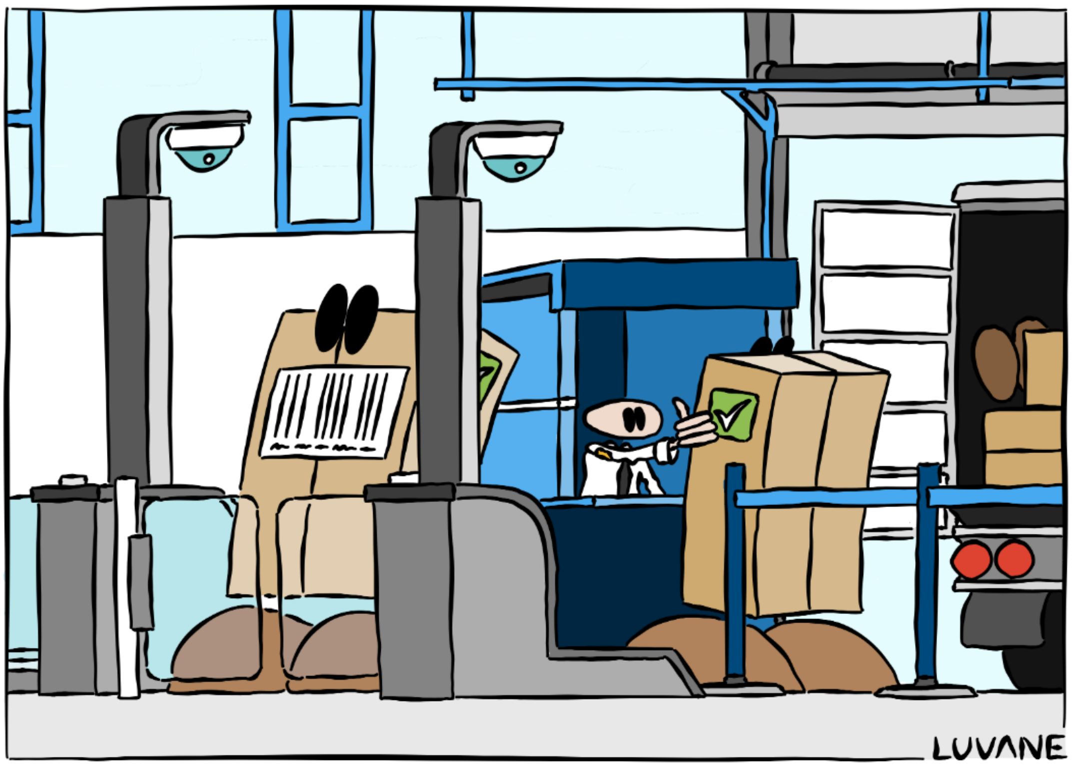
In the slotting application, the product assortment and locations within the distribution center are administered. One of the most time-consuming activities is checking master data. As part of the research project, a software agent is developed based on rule-based machine learning to automatically check the master data. As a result, the workload has been drastically reduced. Only exceptions need to be handled by the user and the data quality improved significantly. In addition, a slotting agent is developed based on reinforcement learning to solve (parts of the) slotting puzzles.

METHODOLOGY

The slotting application is developed by a team of logistics professionals and domain experts using the OutSystems platform and agile development methods. Master students and researchers from the University of Twente conducted industrial- and experimental research based on established scientific methods as part of a 2-year research project. Intermediate results were shared and discussed during regular consortium meetings and the results are published and presented during congresses and industry events.

Project leader	Meints, A.P. (Pieter)
Research performed by	Kloppenburg, G.W. (Wieger), Gemmink, M.W.T. (Martijn)
Partner organizations	Universiteit Twente (UT), CAPE Groep, DeltaGo, Albert Heijn, Kien Logistics Management BV
Part of TKI Dinalog project	Autonomous Logistics Miners for Small- and Medium sized Businesses
Related publication	"Publieke eindrapportage" (2020)

C.3. Data validation with rule-based machine learning



Data validation with rule-based machine learning

Slotting is one of the most customer-sensitive, labor-intensive, and complex problems encountered within different companies. It is the allocation of products in the warehouse based on different rules or strategies. There are many different methods, algorithms, policies, and processes but there is no uniform way of allocating products. Slotting heavily relies on worker's expertise and knowledge. Currently, this time-consuming process is done manually. This research explores the possibilities for (partially) automating this process.

CONTRIBUTION

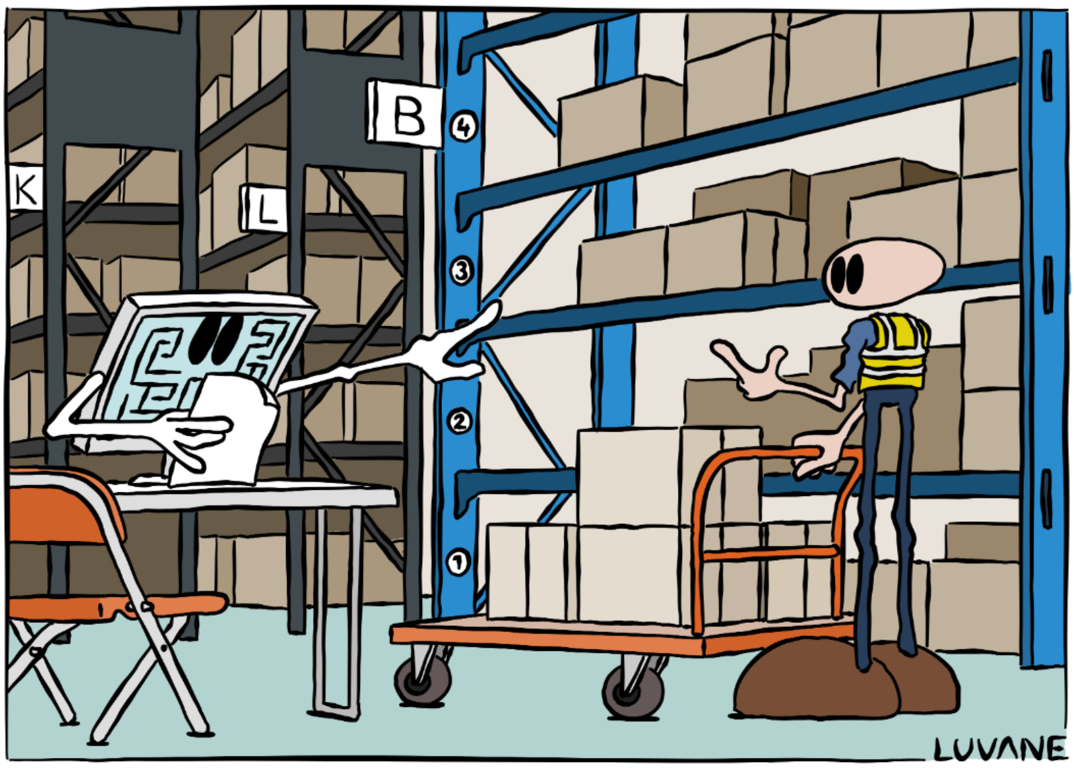
The main contribution of this master project is a reference architecture to automate rule-based tasks based on the concept of intelligence amplification. One of those rule-based tasks of slotting is the data validation of products. A prototype is designed and developed to (partially) automate the data validation. Experimental development and testing of the prototype demonstrate that workers' performance can be enhanced as well as the quality of work in the slotting process.

METHODOLOGY

The master research project is based on the Design Science Research Methodology for Information Systems Research of Peffers et. al. and literature research is carried out based on the rigorous process of Wolfswinkel et al. Case study research is conducted at Albert Heijn. The model for task decomposition of Dobrkovic is used for structured job analysis and agent development. The slotting process is analyzed and split up into different tasks, categorized, and assigned to human and machine.

Research performed by	Kloppenburg, G.W. (Wieger)
Supervised by	Iacob, M.E. (Maria), Van Sinderen, M.J. (Marten), Meints, A.P. (Pieter), Piest, J.P.S. (Sebastian)
Partner organizations	Universiteit Twente (UT), CAPE Groep, DeltaGo, Albert Heijn, Kien Logistics Management BV
Part of TKI Dinalog project	Autonomous Logistics Miners for Small- and Medium sized Businesses
Related publication	"The Adoption of Intelligence Amplification in the Slotting Process: a case study in the data validation automation of a Dutch Retailer" (2019)

C.4. Adoption model for reinforcement learning agents



Adoption model for reinforcement learning agents

Whereas supervised and unsupervised learning have already reached widespread adoption within the logistics industry, reinforcement learning remains a largely uncharted territory. Reinforcement learning is particularly interesting as agents can learn based on experience. Applications of the technique so far focused primarily on games but reinforcement learning could also be implemented within the business processes of logistic organizations. Current adoption models lack the unique determinants for artificial intelligence and reinforcement learning.

CONTRIBUTION

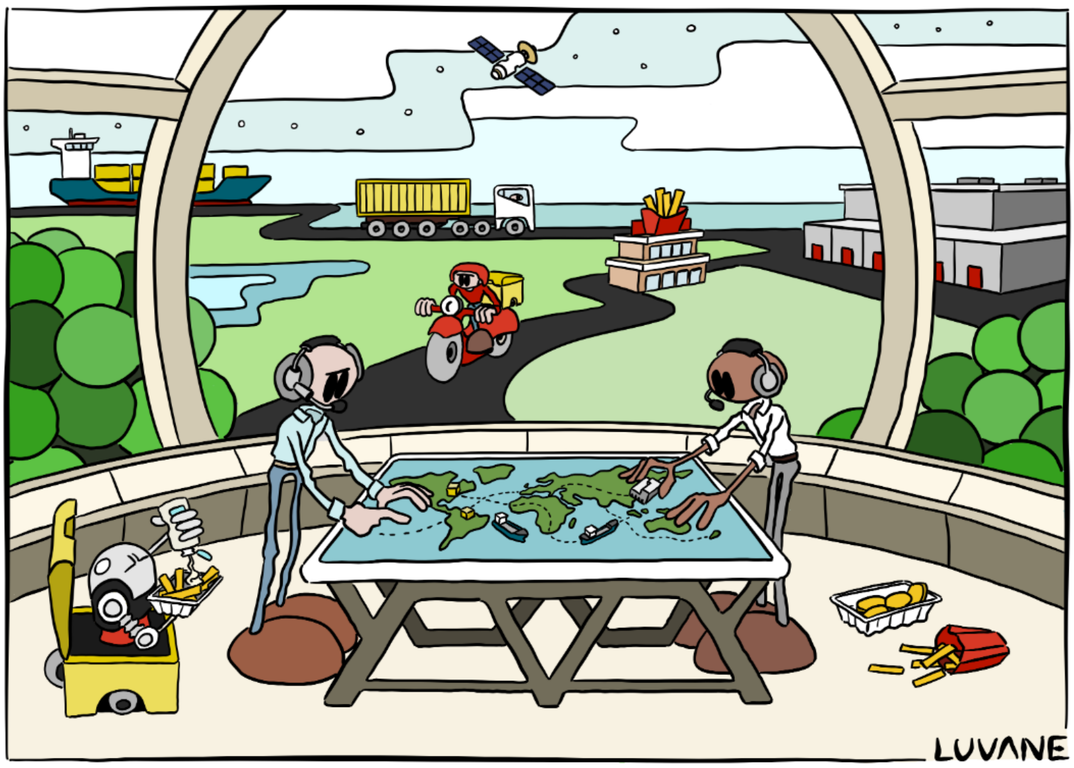
The main contribution of this research is the development of an adoption model for reinforcement learning and example agent that is ready to be used for experimentation. A reinforcement learning agent is designed to solve (a part of) the product allocation problem, also called slotting, within warehouses. The agent successfully learned how to allocate products according to the requirements prioritized by the company. Experiments indicate that agent performance can significantly be improved using intelligence amplification.

METHODOLOGY

The master research project is based on the Design Science Research Methodology of Wieringa. Both exploratory research and a literature review formed the basis for the adoption model. Case study research is carried out at Albert Heijn. The model was validated using expert opinion interviews, case study research, and prototyping. Several reinforcement learning approaches are tested, and the performance of different algorithms is measured and evaluated.

Research performed by	Gemmink, M.W.T. (Martijn)
Supervised by	Iacob, M.E. (Maria), Van Sinderen, M.J. (Marten), Meints, A.P. (Pieter), Piest, J.P.S. (Sebastian)
Partner organizations	Universiteit Twente (UT), CAPE Groep, DeltaGo, Albert Heijn, Kien Logistics Management BV
Part of TKI Dinalog project	Autonomous Logistics Miners for Small- and Medium sized Businesses
Related publication	"The adoption of reinforcement learning in the logistics industry: A case study at a large international retailer." (2019)

C.5. The journey towards control tower 4.0



The journey towards control tower 4.0

Kien Logistics Management is an independent and non-asset-based control tower, operating as an integral part of the Farm Frites supply chain organization. In close cooperation with CAPE Groep, a control tower platform is realized to orchestrate global supply chains. As part of the research project, a roadmap is created to explore the potential of web scraping, robotic process automation, machine learning, and artificial intelligence. The overall aim is to strengthen the control tower platform regarding supply chain visibility and carrier performance monitoring.

CONTRIBUTION

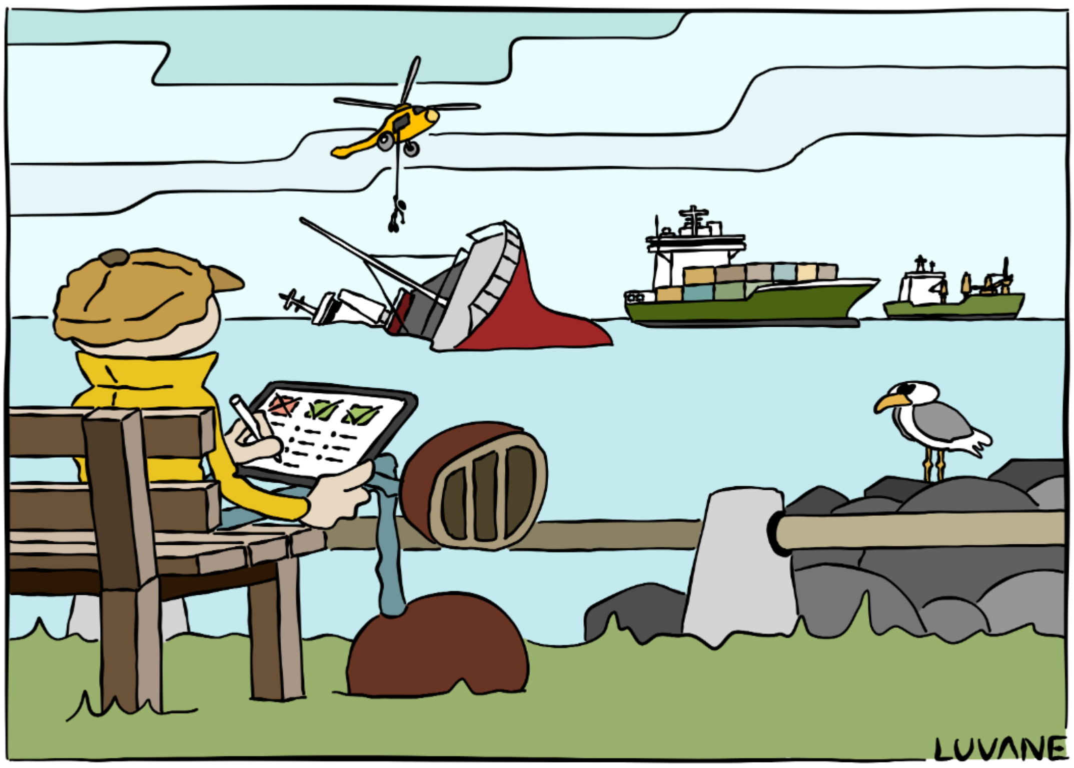
The control tower platform is expanded with web scraping agents, a carrier performance dashboard, and a machine learning application for predicting expected arrival times of container vessels based on historical data with supervised learning. The routine tasks are taken over by the agent but not all tasks are delegated and automated, leaving more time and space for creative and solution-oriented tasks. This way, using the concept of intelligence amplification, efficiency and productivity increases, and the work is made more satisfying and interesting.

METHODOLOGY

The control tower platform is developed by a team of logistics professionals and domain experts of Kien Logistics Management and consultants of CAPE Groep using the Mendix platform and agile development methods. The web scraping agents are developed using Dexi.io and integrated using the eMagiz platform. Bachelor and Master students and researchers from the University of Twente conducted industrial- and experimental research based on established scientific methods as part of a 2-year research project. Intermediate results were shared and discussed during regular consortium meetings and the results are published and presented during congresses.

Project team	Brokke, M. (Michiel), Wesselink, M. (Maik)
Research performed by	Klaassen, W. (Wim), Bussmann, N.H. (Nina)
Partner organizations	Universiteit Twente (UT), CAPE Groep, DeltaGo, Albert Heijn, Kien Logistics Management BV
Part of TKI Dinalog project	Autonomous Logistics Miners for Small- and Medium sized Businesses
Related publication	**"Publieke eindrapportage" (2020)**

C.6. Ocean carrier KPI dashboard



Ocean carrier KPI dashboard

Logistics Service Providers are constantly in search for the best performing carrier for each shipping lane. Carriers are contracted based on price and service level agreements are made with clear KPIs. The measurement and evaluation of carrier performance requires data extraction from multiple sources. Updating KPIs for customers is a manual and time-consuming process. This research aimed to explore possibilities to automate the processes related to KPI calculation.

CONTRIBUTION

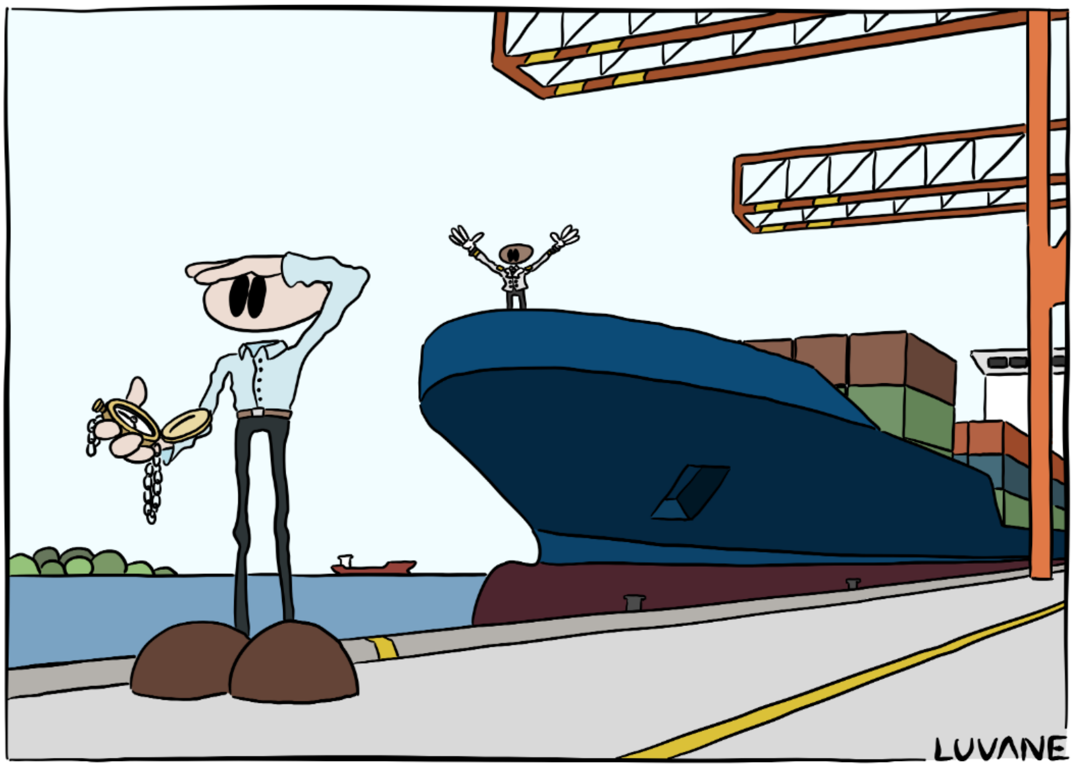
This research contributes to better understanding of available solutions for the visualization and comparison of carrier performance. A general dashboard is created for carrier comparison on specific shipping lanes or areas. Specific dashboards are created to focus on carrier performance and problem routes. The dashboard is incorporated in the control tower platform to support the process of carrier selection and performance evaluation. In addition, a general framework was developed that addresses the different steps to be taken in order to visualize and rank carriers based on performance.

METHODOLOGY

This bachelor project is based on the Design Science Research Methodology for Information Systems Research of Peffers et. al. Literature research was conducted in regard KPI calculation and selection, performance evaluation, and benchmarking of ocean carriers. Rapid prototype and agile development methods were used to develop a prototype of the KPI dashboard. The results are generalized in a framework that allows similar companies to evaluate and compare the performance of carriers.

Research performed by	Klaassen, W. (Wim)
Supervised by	Iacob, M.E. (Maria), Meertens, L.O. (Lucas), Wesselink, M. (Maik), Piest, J.P.S. (Sebastian)
Partner organizations	Universiteit Twente (UT), CAPE Groep, DeltaGo, Albert Heijn, Kien Logistics Management BV
Part of TKI Dinalog project	Autonomous Logistics Miners for Small- and Medium sized Businesses
Related publication	"Visualizing ocean carrier performance : a framework for evaluating logistic partners." (2019)

C.7. Predicting container vessel arrival times



Predicting container vessel arrival times

Logistics plays an important role in global supply chains to fulfil customer demands. The timeliness of deliveries relies on the performance of multiple actors. Up-to-date status information is essential for the planning and coordination of shipments and alignment of business processes. In the context of global forwarding, the sailing schedules of ocean carriers appear to be unreliable. This research project aimed to develop a predictive model based on historical order data.

CONTRIBUTION

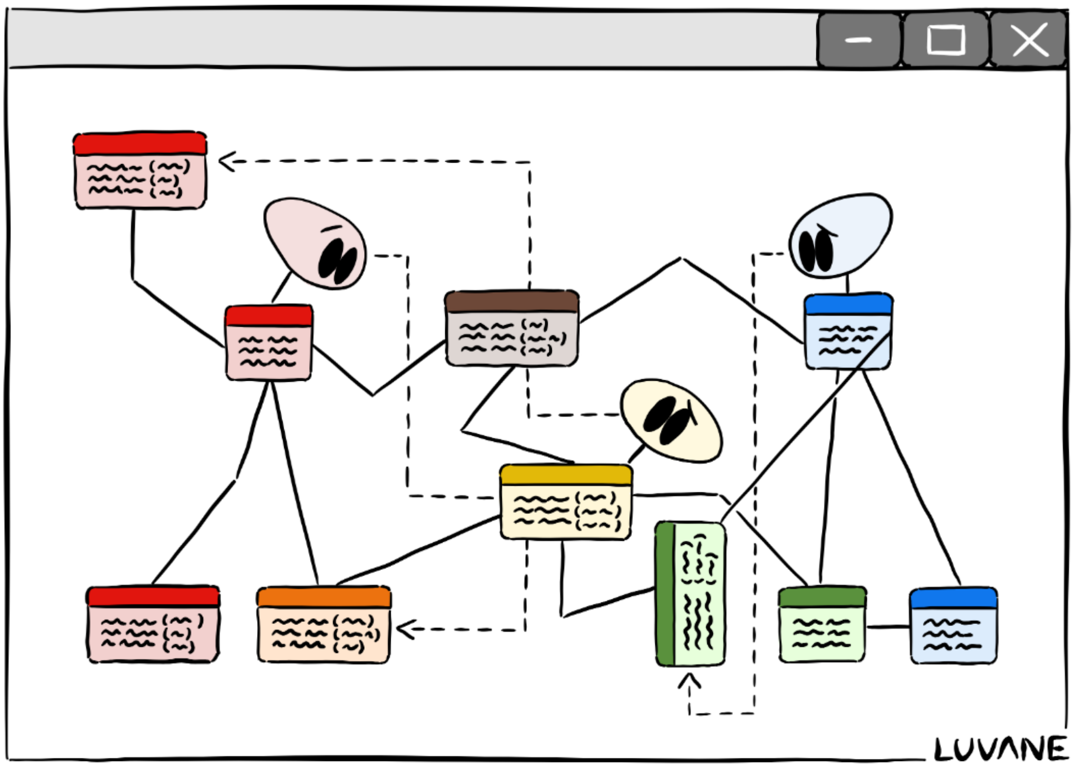
The main contribution of this research is an extensive review and in-depth comparison of available advanced data analytics and modelling techniques. A supervised machine learning approach is developed based on the Random Forest technique. After training and testing the Random Forest, the model accurately predicts deviations in sailing schedules provided by ocean carriers. A predictive web service is deployed and used in the control tower platform. Predictions are made in the planning phase of a shipment for decision support.

METHODOLOGY

This master research project is based on the Cross Reference Industry Standard Process for Data Mining methodology of Chapman et. al. A literature review is conducted regarding arrival time prediction models, data mining, and machine learning. Based on available (historical) data and the data collected with web scraping, the performance of multiple data mining techniques and machine learning algorithms is evaluated. Rapid prototyping and agile development methods are used to develop a prototype.

Research performed by	Bussmann, N.H. (Nina)
Supervised by	Mes, M.R.K. (Martijn), Koot, M. (Martijn), Piest, J.P.S. (Sebastian), Wesselink, M. (Maik)
Partner organizations	Universiteit Twente (UT), CAPE Groep, DeltaGo, Albert Heijn, Kien Logistics Management BV
Part of TKI Dinalog project	Autonomous Logistics Miners for Small- and Medium sized Businesses
Related publication	"Predicting arrival times of containervessels: A machine learning application." (2019)

C.8. Automatic mapping of logistics data



Automatic mapping of logistics data

Achieving interoperability eventually results in the task of mapping different data formats and so-called schema matching. At present, this task is carried out manually. Prior research has proven this task difficult to fully automate, because it requires knowledge of designers and schemas do not necessarily capture all semantics of the data. Early research indicates that intervention can improve mapping results. Validated research in this area however is still in its infancy.

CONTRIBUTION

The main contribution of this research is a reference architecture and prototype using the hybrid integration platform eMagiz and Microsoft machine learning studio. Our research provides a starting point, and a set of guidelines for developing smarter interoperability applications based on automatic schema matching, the concepts of Intelligence Amplification, and machine learning techniques. Preliminary results of the first design and development cycle are encouraging but require additional development and thorough validation.

METHODOLOGY

This research is conducted based on the Design Science Research Methodology for Information Systems Research of Peffers et. al. Using available literature, the problem is investigated and existing approaches have been evaluated. Eventually, a reference architecture for Intelligence Amplification driven schema matching is modelled using the ArchiMate specification and language. The developed prototype demonstrates that it is possible to develop a collaborative approach to schema matching, utilizing the knowledge of the designer and machine intelligence.

Research performed by	Piest, J.P.S. (Sebastian), Meertens, L.O. (Lucas), Buis, J. (Johan), Iacob, M.E. (Maria), Van Sinderen, M.J. (Marten)
Partner organizations	Universiteit Twente (UT), CAPE Groep, DeltaGo, Albert Heijn, Kien Logistics Management BV
Part of TKI Dinalog project	Autonomous Logistics Miners for Small- and Medium sized Businesses
Related publication	"Smarter interoperability based on automatic schema matching and intelligence amplification" (2020)

D. Report of round table discussion (in Dutch)

Vergadering

Raad voor Logistieke Kennis volgt en beoordeelt nieuwe ontwikkelingen en vertaalt dit naar de achterban. Expliciet speerpunt is MKB.

Plan voor de Raad voor Logistiek

Raad bestaat al ruim 10 jaar. Evaluatiegesprekken gevoerd. Zomer gebruikt voor schrijven nieuw plan. Behoefte aan kennisdisseminatie. Ambitieniveau vaststellen. Concretiseren resultaten. Tijdens de raad concrete punten definiëren voor het bureau van Evofenedex.

Peilers en thema's verwerken in praktische overzichten

Er zijn 4 peilers: innovatie, human capital, sociale innovatie, digitalisering. Thema's inventariseren via enquête, inhoud door spreker, voorbereidende stukken, kwaliteit vergadering omhoog. Hele logistieke speelveld meenemen, acties definiëren. Structureren vergadering: mens (opleiding/bijscholing), logistiek (praktijk/organisatie) en overheid (wet/regelgeving). Kansen en bedreigingen. Termijn vaststellen (kort-middellang-lang). AI staat in de top 3 en vandaag op de agenda.

10 minuten presentatie over AI in de Logistiek en toepassing bij Kien Logistics Management

Stelling 1: "De hyper operationele focus van logistiek werkt de adoptie van strategische innovaties zoals AI tegen"

LSP1: Ben het ermee eens, breder werkt het innovatie tegen. Het moet bewezen technologie zijn.
Retailer 1: Niet mee eens. Overal waar een BC voor te maken is, gaan we mee aan de slag. Tijdgeest en plek in de innovatiecurve speelt mee. BC moet zich wel snel terugverdienen. Nieuwe generatie logistiekelingen vraagt zich af of het een probleem is, kijken heel anders naar beschikbare technologie. Krapte op de arbeidsmarkt gaat nu meewerken in de introductie van AI.
Retailer 2: Langere termijn bij verladers, operationele focus herken ik minder. Development afdelingen steeds groter. Centraal steeds meer. Waar zet je op in en wanneer? Vb. drones, kan niet overal pilots en innovaties voor doen. Robotisering duurt lang. Daarnaast nieuwe intreders zoals Picnic, komen snel binnen en pakken markt. Die hebben geen legacy en afschrijvingen. Kom uit een wereld van lean, six sigma, we moeten processen slimmer maken en wasteless maken. Met een wasteless proces heb ik geen robot voor nodig. Typerend, nieuwerwetse technologie inzetten versus procesefficiency.

Recruiter: tijd en ruimte is erg dun, risico om te verliezen is te groot. Sector is gedreven door controle en behoud. Risicodragende budgetten staan onder druk. Iedere disruptie ga je angstvallig uit de weg. Iemand die nieuw start heeft meer bewegingsvrijheid.

Manufacturer: grote verscheidenheid aan bedrijven, wij doen zelfstandig logistiek en projecten, wij hebben geen SC denktanks, geldt voor het MKB. Daarnaast logistieke mensen zijn geen innovators. Rendementen moeten gehaald worden. Beursgenoteerd zijn leidt tot korte termijn denken, kijken niet verder dan 3 maanden vooruit. Toevallige spinn-off, demonstreren we hier wederom dat logistiek een cost center is? Moet het de logistiek niet helpen om waarde te creëren? Hyper operationele focus speelt bij MKB'ers: hoe pak je dat aan?

Energy producer: hardcore operators drijven innovatie boven op de overdrukke dagen en steken graag extra tijd in verbetering. Dat komt niet vanuit een data scientist. We zoeken naar kleine verbeteringen. Automatiseren is een oud en lelijk woord. De data is er, waarom krijgen we dat niet op het scherm? Het zetten van de eerste stap creëert de vervolgstap. Transformatie naar de future machine vraagt om openheid in eigen proces en aanpassingsvermogen. Thuis ben je daarnaast beter geautomatiseerd dan op het kantoor. Het gaat niet over techniek.

Professor: waarom is het een strategisch thema? AI is groots, niet 1 discipline of 1 technologie en vergt een visie. Ik lees hier heel iets anders in, wat heeft AI met klantwaarde te maken? Logistiek gaat over kosten, efficiency, morgen ROI. Waardedenken zit er niet bij. Als het morgen kan ok, anders rommelen we door.

Forwarder: Tyfoons en congestie in havens ga je niet oplossen, met webscraping technologie detecteren we dit sneller en met AI kunnen we meer voorspelbaarheid in de keten creëren o.b.v. alle data die we beschikbaar hebben en kunnen minen. Hoe kunnen we met alle beschikbare data en robotisering de stap maken van handmatig passief naar automatisch pro-actief de klanten informeren over events in de keten en laten anticiperen op de gevolgen. Voorspelbaarheid in de keten vergroot klantwaarde.

Stelling 2: "Er is leger aan data scientists nodig om de logistiek klaar te stomen voor AI"

Evofenedex: data scientist heeft capabilities wel, maar niet het inzicht/creativiteit om een business case te vinden. Hoeveel bedrijven binnen Evofenedex zijn hier nu mee bezig?

Retailer 2: logistiekeling kan geen regressie doen, komen econometristen binnen die formules schrijven die ik niet zou maken, skillset van mensen in de logistiek is aan het veranderen, niet alleen AI, ook netwerkanalyses bijvoorbeeld.

LSP1: gaat wellicht nog even duren, maar staat het internet niet bol van libraries die je bij elkaar kan klikken. De gemiddelde scholier kan dit nu al. Software robotics klinkt moeilijk, maar kun je in blokken op het web bij elkaar verzamelen toch?

<u>Professor:</u> logistiek moet dit soort nieuwe concepten snappen en op waarde kunnen inschatten en dan samen met experts implementeren, logistiekeling wordt steeds meer data scientist en minder van heftrucks en trucks. Grosso modo, logistiek heeft een beperkt innovatief vermogen. Percentage koplopers is klein, grote middenmoot met MKB. Hebben how-to nodig, demonstrators, show cases zoals die van Kien.

<u>Forwarder:</u> sluit aan op onze ervaring, hebben een data analyst en logistiek engineer in dienst, business case komt vanuit proceskennis, in welke stap voeg je welke data toe, wat wordt er met die data gedaan, zij teamen met de IT ontwikkelaars. Automatisering/robotisering gaat niet zonder procesbeheersing. Mensen kunnen anders niet de juiste keuze maken. 4 jaar terug lag de druk op operational support. Grote operationele bulk verplaatst zich naar intelligente besluitvorming. Dat gaat een andere mindset vragen van de mensen.

<u>Recruiter:</u> ABN heeft een studie gedaan, innovaties gaat heel en komen, maar de impact voor de logistiek valt bijzonder mee. Te ver weg, te abstract.

<u>Distributor:</u> toen ik bij CEVA werkte werden verbeterkansen niet gepakt, toen ik bij Philips zat snapte ik dat beter vanwege aandeel in logistieke kosten. Daarnaast zitten IT afdelingen vol.

<u>Manufacturer:</u> we zitten onszelf vooral in de weg in de logistiek, wat zijn factoren die de innovatie tegen gaan? De houding t.o.v. nieuwe technologie is afwachtend, moet eerst bewezen zijn.

Stelling 3: “Sociale innovatie en aandacht voor de menselijke aspecten is velen malen belangrijker dan de technologische innovatie”

<u>Energy producer:</u> mooi item onderweg hierheen op de radio over de beroepen van de toekomst, empathische kant van de mens en interactie, dat worden de nieuwe beroepen, rest door robots en automatisering. Vraag is hoe je de mensen meeneemt?

<u>Recruiter:</u> aantal banen verdubbeld, vervangingsbanen zien we niet. Het een gaat niet zonder het andere. Sociale innovatie is een randvoorwaarde voor technologische innovatie, niet per definitie belangrijker. Je zult echter ergens moeten beginnen. Skill set gaat wijzigen; je weet wat je kon, weet je wat je moet kunnen straks? Mobiliseren van skills/talent is essentieel, niet alleen voor bedrijven.

<u>Evofenedex:</u> sociale innovatie gaat toch veel meer over het aanspreken van het potentieel van mensen, het is niet per definitie iets voor de logistiekeling?

<u>Retailer 2:</u> mate van innovatie is sterk gekoppeld aan de mate waarin je mensen aan je weet te binden, medewerkers hebben minder binding aan een bedrijf, zoeken uitdaging bij meerdere bedrijven. Hoe zorg je voor borging?

<u>Professor:</u> deming regel, take away fear, sociale innovatie neemt mensen mee in het doel, niet weg automatiseren, we zullen voor je zorgen.

Stelling 4: “Het is belangrijker dat er vanuit brancheverenigingen een visie op AI wordt ontwikkeld, dan dat er wet- en regelgeving komt”

Retailer 1: moeten vooral voorbeelden komen, bij elkaar gaan kijken hoe het werkt.

Recruiter: delen best practices belangrijker inderdaad.

Distributor: weerbastig, LDVers hebben schitterende powerpoints, maar als ik vraag waar ik mag kijken is vaak onbeantwoord.

Retailer 2: geen AI wetgeving, los het op in de markt, maar wat het belemmert aanpakken, moeten een klimaat creëren waarbinnen we kunnen experimenteren.

Energy producer: wie is waar aansprakelijk in de keten, wie is eigenaar van de data op welk moment, wanneer draag je het over, daar moet helderheid over komen en jurispredictie.

Manufacturer: AI wetgeving is volgens mij niet het probleem, de praktijk moet eerst meer voortschrijden, bij atonomous driving is dat een ander verhaal, maar kunnen best vooruit met de huidige stand.

Evofenedex: visie moet ook een inspiratiebron hebben voor nieuwe innovaties, bijvoorbeeld living labs, het is nu echt het moment om iets te gaan doen, zinvol regisseren is essentieel, hubs bouwen en data delen, voorbeelden zoals ishare en de digitale vrachtbrief moet vervolgens wel toegepast worden. Vanuit duurzaamheid/efficiency wordt het straks een license to operate.

Wrap-up

Stelling 1: aantal toepassingen zijn er al, maar er is ook een groot gat met de achterban. Hoe dichten we dat gat? Evofenedex zou aantal koplopers moeten identificeren en in kaart brengen. Hoort een visie bij, maar moet ook klein en praktisch gemaakt worden.

Stelling 2: het is nog niet af, maar er is veel enthousiasme, waar begin je? Disciplines en generaties bij elkaar brengen.

Stelling 3: jongere generaties zijn slimmer en sneller met IT dan docenten, er zijn grote verschillen tussen de generaties, gaat zo snel dat lespakketten zijn snel verouderd, case studies uit de praktijk de klas inhalen.

Stelling 4: inspiratie nodig voor middenlaag met pakkende voorbeelden, focus op standaardisatie m.b.t. data delen en contracten, zit veel wetgeving in, verbinding zoeken met projecten zoals compose en ontsluiten naar MKB.

E. Safety and risk assessment

The Safety Cube Method (SCM) of Rajabalinejad (2018) is a systematic approach to assess safety and risk aspects and results in a safety cube. The safety cube consists of six tiles and offers a practical instrument to identify and classify safety and risks aspects and interrelate these aspects to stakeholders in the business system, containing system and wider environment. The SCM and safety cube are used to conduct a systematic safety and risk assessment of the industry platform. Next, in E.1. the six tiles of the safety cube are discussed, and the created safety cube is presented. Then, in E.2. the results of the risk assessment of the industry platform are documented.

E.1. Safety Cube Method

1. System scope and limits

The scope of the system of interest is an industry platform for SMEs in the Dutch logistics industry. The system is focused on data-driven logistics applications and integration with systems of SMEs. Thus, it is an analytical application that supports decision support, but does not directly interfere operational processes or physical products.

2. Humans associated with the system

Based on the stakeholder analysis, two types of end-users are identified (transport planner, business analyst) that will be provided access to the industry platform. Additionally, the system administrator (IT support employee), supporting staff (external IT specialist) and systems integrator (external integration specialist) will have access to the industry platform. The remaining stakeholders are involved during the contracting, development and/or implementation of the industry platform or are associated indirectly with the system.

3. System environment

Based on the stakeholder analysis, the main actors in the system environment are shippers, LSPs, transport operators, logistics platforms and EDI brokers. The containing system and wider environment are identified, classified, and specified in a detailed list of human beneficiaries and connected systems. In the case that the system will be deployed, the other stakeholders will be involved, including clients, suppliers, regulators, competitors, substitute products and threat agents.

4. System-environment relations

The main actors, their systems and interfaces with the platform are identified and visualized in **Figure 13**. Shippers create interfaces with their ERP/WMS system and the platform and utilize the systems integration to exchange transactions with LSPs. LSPs connect their TMS/APS and board computers to the platform and are the intermediate between shippers, their fleet, and/or external transport operators. Transport operators connect their TMS/board computer to the platform to receive shipment instructions from LSPs and report the position and status. The system can be connected to logistics information platforms and exchange data with other actors via EDI brokers.

5. Human-systems relations

Based on the stakeholder analysis a detailed overview is provided of the stakeholder goals. The 28 requirements describe the most important relations of users, developers, and beneficiaries in terms of product roles (normal operator, operational support and system integrator).

6. Human-environment relations

Based on the stakeholder analysis and the program of requirements, the functional and political beneficiaries maintain important human-environment relations in the wider environment. Furthermore, regulators can enforce new requirements for the platform and treat agents can negatively influence the performance of the system.

Safety cube

Based on the application of the SCM, the safety cube is created and depicted in **Table 26**.

Safety cube	Human	System	Environment
Human	User, system administrator, support staff	Normal operator, operational support, maintenance operator, system integrator	Client, supplier, external developers, reseller, branch organization, regulator, competitor, cyber criminal
System	Manual inputs, platform functions, solve errors	Application Programming Interface (API) connections, connected systems, solve connection errors	Interoperability scenarios with actors in the environment and choreographies
Supersystem / environment	Standard inputs, certified functions	Standardized interfaces and certified connectors	Unification of interface definitions in the industry, policies, and regulations for data exchange

Table 26: Safety cube for the platform, stakeholders, and environment.

E.2. Risk management

In this section, the SCM and safety cube are utilized as a starting point for risk assessment, reduction, and communication. **Table 27** presents an overview of the 15 aspects that are assessed.

Functional aspects	Technical aspects	Operational aspects
1. Stakeholders and needs 2. System concept, definition, and environment 3. System safety objectives 4. Safety-risk assessment and acceptance criteria 5. Specification of system (safety) functions and requirements	6. Architecting a (safe) system 7. System (safety) design 8. Residual safety-risk acceptance 9. Production, integration, test, and validation 10. Packaging, transportation, installation, certification, and preparation for operation	11. Operation and required performance 12. Maintenance, support, faults, and logistics 13. Human factors and culture 14. Safety -risk monitoring, control, and communication 15. Retirement, disposal, or re-use

Table 27: Risk management assessment.

Functional aspects – risk assessment

The first five steps are executed and documented in this subsection to describe the functional aspects and conduct a risk assessment.

1. Stakeholders and their needs

In the previous section, an overview is presented of the stakeholders related to the business system (4 stakeholders), containing system (4 stakeholders) and wider environment (9 stakeholders). The requirements overview lists and classifies 28 requirements for the business and containing system. The goals and constraints are incorporated in this overview.

2. System concept, definition, and environment

A typical interoperability scenario, presented in **Figure 13**, places the system of interest in context. The stakeholder overview, visualized in **Figure 14** and described in **Table 5**, further describes the direct and wider environment. In **Chapter 6**, an overview is presented of the layered systems architecture and a detailed view of the developed systems. Here, the functionality is described in detail, covering the 5 main components and interfaces.

3. System safety objectives

The main focus will be on digital safety and realizing cybersecurity objectives. The main objectives related to safety and risk management are related to system and data availability (measured in % uptime) and integrity (measured in data loss), connected systems (measured in % API service uptime), applicable law and regulation (measured in data breaches) and protection against cyber-threats (measured in attempts). The safety and risk levels are categorized and shown in **Table 28**.

Level	Category	Exemplar events and effects
1	Catastrophic	Loss of the system and all user data, leading to lawsuits, financial claims, and loss of clients, affecting the continuity of the platform company and possible bankruptcy.
2	Critical	Data breach disclosing user data, system and services (e.g., APIs) unavailable for week or more, significant loss of data, leading to rework, distrust and unsatisfactory clients, potential loss of clients and affecting the reputation of the platform company.
3	Minor	System and service down-time for one-day, leading to partial loss of data, rework, and unsatisfactory clients, affecting the reputation of the platform company.
4	Negligible	Data quality issues as a result of user mistakes.

Table 28: Overview of safety risks.

Because the aim is to develop an industry platform, for a broad group of SMEs, individual user behaviour can potentially affect other users. Therefore, the main objective is to ensure separation of concerns and govern data sovereignty.

4. Safety-risk assessment and acceptance criteria

Based on the previous step, hazards are identified based on a brainstorm with system developers. **Table 29** presents an overview of the identified hazards.

Category	Occurrence	Hazard	Exemplar event
A	Frequent	Data quality issue	Typo in user input, incomplete data, missing fields, duplicate data
B	Probable	Data loss	User input not stored, ETL transaction fails, API requests fails
C	Occasional	System crash	Application, database, interfaces stop working
		Algorithm malfunctioning	Model performance drops, inaccurate predictions

D	Remote	Data breach	User data disclosed
	Remote	System loss	Infrastructure gets on fire or overheated

Table 29: Overview of identified hazards.

5. Specification of system (safety) functions and requirements

The safety related requirements are specified in S2 (Monitor the performance and health of the system and integrations), S4 (Solve technical issues independently), C3 (Documentation for external developers), T3 (Compliant to industry standards), T4 (Ensure data sovereignty), T5 (Scalability), T6 (Cybersecurity), L1 (Compliant to laws and regulations), L2 (Compliance to GDPR) and L3 (Audit log and authorizations).

Technical aspects – risk reduction

Based on functional aspects covered by step 1-5, five additional steps are executed and documented in this subsection to describe the technical aspects for risk reduction.

6. Architecting a (safe) system

Based on step 1-5, the following functions and requirements can be incorporated in the system architecture to improve the safety and reduce risks:

- High availability: clustering, load balancing;
- Redundancy: message queuing, fail-over and deployment in multiple cloud locations;
- Decoupling: separating concerns of application, database, and interfaces;
- 2-factor authentication: preventing non-authorized users to access user data;
- Authorization register: policies and access controls for users and connected systems;
- Intrusion detection subsystem: incorporate a subsystem to detect intruders.

Most of these functions are provided by cloud infrastructure services providers (e.g., Microsoft Azure, Amazon Web Services) and can be incorporated in the design of the industry platform as general platform services.

7. System (safety) design

Based on the previous step, the following design aspects and interventions can be incorporated:

- Safety requirements: gather, classify, and elicit requirements for safety and risk;
- Design patterns: incorporate safety by design patterns in developers' guidelines;
- User certification: require user training and/or solution testing prior use of the system;
- Procedures: offer users, support staff and system integrators safety and risk procedures;

- User auditing: periodically audit the use of the system to identify and mitigate risks;
- Risk and incident logging: administer and periodically assess risks and incidents;
- Penetration testing: assess vulnerabilities via external party or ethical hacker ;
- Cyber assessment: periodically assess cybersecurity.

8. Residual safety-risk acceptance

Based on step 6 and 7, the following interventions can be considered to foster acceptance:

- Certification: ensure a level of quality via certification bodies (e.g., ISO);
- Contracts: formalize agreements about software, hardware, and services (e.g., SLA);
- System review: periodically assessment of performance, vulnerabilities, risks, and safety;
- Preventive actions: release security updates, patches and educate users to prevent issues;
- Claim handling: have a structured and effective procedure for claim handling.

9. Production, integration, test, and validation

Based on step 7-8 the following interventions can be considered:

- R&D procedures: incorporate the contents in formal R&D procedures with checks;
- Developer tests: formalize developer guidelines in unit, function, integration tests;
- Developer certification: formalize training requirements, solution testing and validation;
- User validation: involve users in testing and validation of new features.

10. Packaging, transportation, installation, certification, and preparation for operation

Complement the platform based on step 6-9 with the following deliverables:

- Product documentation: manual for users of the industry platform and intended use;
- Legal documentation: usage policies, terms and agreements, warranty, and disclaimer;
- Quality assurance: policies and procedures;
- Training and certification program: for users and developers;
- Roadmap: release schedule of the platform, including update policies and agreements.

Operational aspects – communication

Based on the functional and technical aspects covered by step 1-10, five additional steps are executed and documented in this subsection to describe the operational aspects to communicate risks.

11. Operation and required performance

Based on the previous steps, the following interventions can be considered here:

- User instruction: best practices for intended use, walkthrough guides and tutorials;
- Product demonstrations: marketing material to introduce new features.

12. Maintenance, support, faults, and logistics

Based on the previous steps, the following interventions can be considered here:

- Ticketing system: to report incidents, faults, errors;
- Service portal: to request (remote) assistance and professional services and support;
- Training and certification: system administrator
- Instructions: to guide product updates, patches, and bug fixes;
- Yearly maintenance: planning and best practices for upgrade/update the platform.

13. Human factors and culture

Based on the previous steps, the following interventions can be considered here:

- Best practice sharing educating users/developers about intended use of the platform;
- Awareness: training and audits to govern cybersecurity;
- Culture: foster a safety and risk management culture from leadership to employees;
- Acknowledge intended use: provide incentives for detecting and reporting of incidents.

14. Safety -risk monitoring, control, and communication

Based on the previous steps, the following interventions can be considered here:

- Set-up a control system: to monitor use and performance of the platform;
- Log: track incidents and suspicious behaviour;
- Periodical assessment: of risks, vulnerabilities, and developments in the environment;
- Communication plan: based on yearly roadmap, product releases and patches.

15. Retirement, disposal, or re-use

Based on the previous steps, the following interventions can be considered here:

- Re-use: Data export and transfer policy;
- Exit agreement: to transition to alternative platform

F. Ethical assessment

The Ethics Guidelines contribute to developing trustworthy AI applications that are lawful, ethical, and robust. Lawful means AI applications need to comply with applicable laws and regulations. These can be primary laws, secondary laws such as GPDR or specific product or domain related regulations (e.g., medical equipment). Ethical refers to principles, norms, and values. The common foundation is that AI applications must be human centric. More specifically, respect for human autonomy, prevention of harm, fairness and explicability are considered important design principles. Robustness is assessed from both a technological and societal perspective as part of so-called a socio-technical environment. Designers should ensure that AI applications are safe, secure, and reliable and carefully consider the impact of AI in situations with particularly vulnerable (groups of) people. Furthermore, designers should be aware that AI also poses risks with potentially large negative impact or unintended effects. Ideally, the three core components support and complement each other and are mapped throughout the lifecycle of an AI application.

The core principles for trustworthy AI are translated into 7 design requirements and an (non-exhaustive) assessment list to guide designers in the process of developing, deploying, and using AI applications. The following requirements are assessed 1) Human agency and oversight, 2) Technical robustness and safety, 3) Privacy and data governance, 4) Transparency, 5) Diversity, non-discrimination, and fairness, 6) Societal and environmental wellbeing, and 7) Accountability.

1. Human agency and oversight

All AI applications must be based on human autonomy to ensure human agency and oversight. This connects very well to the concept IA and governance mechanisms such as human in the loop and human in command. Furthermore, AI applications must respect fundamental rights and freedoms of people. Therefore, impact and risk assessments must be conducted, and feedback mechanisms should be put in place throughout the full lifecycle of an AI application.

2. Technical robustness and safety

Technical robustness concerns technical aspects such as accuracy, reliability, and reproducibility, but is also strongly related to the principle of preventing (unintended) harm and protecting humans that interact with the AI application. Furthermore, resilience is an important design aspect to protect against threat agents in the broad sense (e.g., artificial and human). More specifically, this includes resilience to (cyber-)attacks and security breaches, having a fallback plan and governing general safety.

3. Privacy and data governance

Privacy is a fundamental right and data governance should be considered over the full lifecycle of an AI application. More specific, AI applications must respect user privacy, ensure quality and integrity of data, and provide secure access to data based on access protocols. This is related to data sovereignty. Data governance must be ensured for both the data within the AI application and data being collected about users. Special attention must be paid to data concerning people, their behaviour, and preferences. Trustworthy AI applications ensure privacy and avoid unfair, unlawfully use of data.

4. Transparency

Transparency is related to the principle of explicitability of the AI application, the data and business model. More specific, traceability, explainability, and communication are important design aspects. Traceability must be part of the AI application, providing insight in the processing of raw data towards decision-making. Explainability concerns both the technical process and its outcomes of the AI application as well as the decision-making process and its (expected) impact. Communication of the AI application's capabilities and limitations is essential to inform humans about the AI application intended use and impact.

5. Diversity, non-discrimination, and fairness

Trustworthy AI is inclusive and considers all stakeholders throughout the lifecycle. More specific, the avoidance of unfair bias, accessibility and universal design, and stakeholder participation are important design aspects. Therefore, the data, features and labels must be checked on (historical) bias, incompleteness, and inadequate governance to prevent harm. AI applications must be based on universal design principles to be human centric and be accessible for the widest possible range of users. Stakeholders should be involved during the design and development process and regularly feedback moments are beneficial, not just during development, but also after deployment to monitor the use and performance.

6. Societal and environmental wellbeing

The broader societal impact and environment must be considered when design AI applications. More specific, sustainability and environmental friendliness, social impact, society, and democracy are important design aspects. Energy and resource consumption and the supply chain of AI applications should be assessed and optimized. Unnecessary consumption of computational resources should be avoided and is considered to be digital waste. Social agency must prevent harm for people's wellbeing and relations. The societal impact should be assessed considering institutions, democracy and society at large.

7. Accountability

Mechanism must be in place to take responsibility regarding the outcomes of the AI application. More specifically, auditability, minimisation and reporting of negative impact, trade-offs and redress are important design aspects. Extending transparency, auditability enables assessment and evaluation of the algorithms, both raw and processed data and design of the AI application. Impact assessment and reporting must cover the full lifecycle to minimize (potential) negative impact. During the design and realization tension may arise, which can lead to trade-offs. Mechanisms for redress should be in place, especially to ensure trust, prevent harm and protect vulnerable persons and groups.

G. Literature review protocol

This appendix documents the application of the eight-step guide for conducting the literature review based on **Section 4.1**.

Step 1: Purpose of the review

In this PDEng thesis, the focus lies on technological design and SMEs in the logistics industry. Therefore, the literature review aims to identify relevant literature that can be used to develop theory ingrained artefacts for SMEs in the logistics industry. Thus, the literature review is not used for theory development. Data use and technology adoption are studied in multiple disciplines, including (but not limited to) information systems, computer science, psychology, business and economics. For the purpose of this review, the main focus is put on enterprise architecture and technology adoption in SMEs and reviewing the use of data-driven approaches in logistics.

Step 2: Protocol and training

Relevant scientific databases are selected for step 3 for searching literature. Queries and inclusion criteria are created for the practical search for step 4. The results are refined based on exclusion criteria in step 5. The selected documents are retrieved in step 6, including references and citations, and synthesized in step 7. The results of step 8 are incorporated in this PDEng thesis.

Step 3: Searching for literature

Table 30 contains the scientific databases that were used for searching the literature.

Scientific database	Records	URL
Scopus	81.000.000+ (no exact number found)	https://www.scopus.com
IEEE Xplore	5.599.378	https://ieeexplore.ieee.org/

Table 30: Selected databases for the literature review.

The search is conducted throughout the PDEng trajectory and repeated on 27-03-2022.

Step 4: Practical screening

Table 31 presents the template that is used to present the initial results of the practical screening.

Database	Scopus			IEEE Xplore		
	Results	Open	Inclusion	Results	Open	Inclusion
TITLE-ABS-KEY ("..." AND ...)						
TITLE-ABS-KEY ("..." AND ...)						
Total						

Table 31: Template to present results of practical screening of literature.

Filters were set to “All Open Access” in Scopus and “Open Access Only” in IEEE Xplore. The following inclusion criteria are used.

- Documents should be open access for everyone to repeat the search;
- Documents should be available in the English language;
- Documents should be conference papers, journal articles or scientific book(chapter)s.

Table 32 presents the search results regarding enterprise architecture and technology adoption in SMEs in the selected databases and available open access articles.

Database	**Scopus**			**IEEE Xplore**		
	Results	**Open**	**Inclusion**	**Results**	**Open**	**Inclusion**
TITLE-ABS-KEY ("enterprise architecture" AND smes)	71	15	14	10	-	-
TITLE-ABS-KEY ("technology adoption" AND smes)	438	114	112	40	-	-
Total	**509 (100%)**	**129 (25%)**	**126 (25%)**	**50 (100%)**	**- (0%)**	**- (%)**

Table 32: Search results for enterprise architecture and technology adoption in SMEs.

Table 33 presents the search results regarding data analytics and data mining in logistics in the selected databases and available open access articles.

Database	**Scopus**			**IEEE Xplore**		
	Results	**Open**	**Inclusion**	**Results**	**Open**	**Inclusion**
TITLE-ABS-KEY ("data analytics" AND logistics)	566	164	158	152	11	11
TITLE-ABS-KEY ("data mining" AND logistics)	4015	1162	1141	1335	44	44
Total	**4581 (100%)**	**1305 (29%)**	**1308 (28%)**	**1487 (100%)**	**55 (4%)**	**55 (4%)**

Table 33: Search results for data analytics and -mining in logistics.

Table 34 presents the search results regarding process mining in logistics in the selected databases and available open access articles.

Database	**Scopus**			**IEEE Xplore**		
	Results	**Open**	**Inclusion**	**Results**	**Open**	**Inclusion**
TITLE-ABS-KEY ("process mining" AND logistics)	94	28	28	19	1	1
Total	**94 (100%)**	**28 (30%)**	**28 (30%)**	**19 (100%)**	**1 (5%)**	**1 (5%)**

Table 34: Search results for process mining in logistics.

Table 35 presents the search results regarding interoperability in logistics in the selected databases and available open access articles

Database	Scopus			IEEE Xplore		
	Results	Open	Inclusion	Results	Open	Inclusion
TITLE-ABS-KEY ("interoperability" AND logistics)	589	113	111	156	2	2
Total	**589 (100%)**	**113 (19%)**	**111 (19%)**	**156 (100%)**	**2 (1%)**	**2 (1%)**

Table 35: Search results for interoperability in logistics.

Table 36 presents the search results regarding artificial intelligence in logistics in the selected databases and available open access articles.

Database	Scopus			IEEE Xplore		
	Results	Open	Inclusion	Results	Open	Inclusion
TITLE-ABS-KEY ("artificial intelligence" AND logistics)	5157	1480	1450	3013	256	256
TITLE-ABS-KEY ("machine learning" AND logistics)	12990	5488	5407	1676	83	83
TITLE-ABS-KEY ("deep learning" AND logistics)	2163	899	884	346	43	43
TITLE-ABS-KEY ("reinforcement learning" AND logistics)	277	99	97	112	7	7
TITLE-ABS-KEY ("federated learning" AND logistics)	35	15	15	7	2	2
Total	**20622 (100%)**	**7981 (39%)**	**7853 (38%)**	**5154 (100%)**	**391 (8%)**	**391 (8%)**

Table 36: Search results for articicical intelligence and branches in logistics.

Table 37 presents the search results regarding performance measurement and KPIs in logistics in the selected databases and available open access articles

Database	Scopus			IEEE Xplore		
	Results	Open	Inclusion	Results	Open	Inclusion
TITLE-ABS-KEY ("performance measurement" AND logistics)	779	212	209	73	-	-
TITLE-ABS-KEY ("kpis" AND logistics)	171	53	53	32	1	1
Total	**950 (100%)**	**265 (28%)**	**262 (28%)**	**105 (100%)**	**1 (1%)**	**1 (1%)**

Table 37: Search results for performance measurement and KPIs in logistics.

Step 5: Quality appraisal

The following exclusion criteria are used to select relevant documents:

- The title, abstract or keywords of the document should contain (one of) the search terms;
- The document addresses the main research topics and does not mention it as a side topic;
- The document should either contain an original contribution or contain a review with reference(s) to relevant documents;
- The document can be connected to (one of) the research questions.

Step 6: Data extraction

Based on step 4 and 5, selected documents are extracted from the databases.

Step 7: Synthesis of results

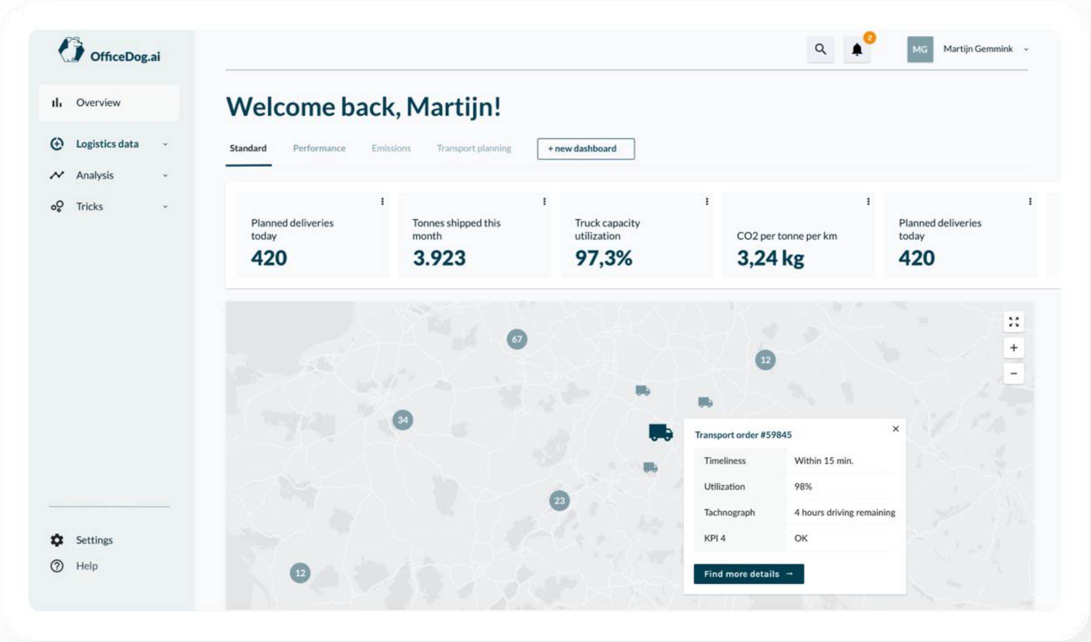
Based on the iterative approach of Verschuren and Doorewaard (2015), described in **Section 4.1**, the results are synthesized.

Step 8: Writing the review

The results are incorporated in in **Section 4.2 – 4.7.**

H. Mock-ups of the platform

This appendix contains the mock-ups that were created to support the development process.



Welcome back, Martijn!

Planned deliveries today
420

Tonnes shipped this month
3.923

Truck capacity utilization
97,3%

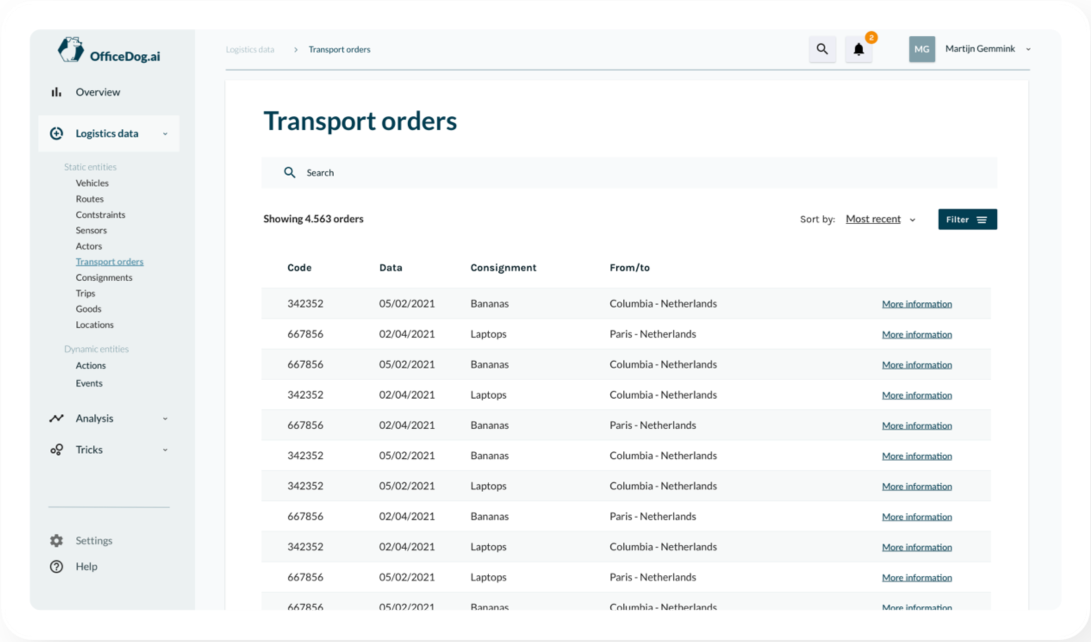
CO2 per tonne per km
3,24 kg

Planned deliveries today
420

Transport order #59845

Timeliness	Within 15 min.
Utilization	98%
Tachnograph	4 hours driving remaining
KPI 4	OK

Figure 67: Mock-up of the user dashboard with KPIs and a live map.



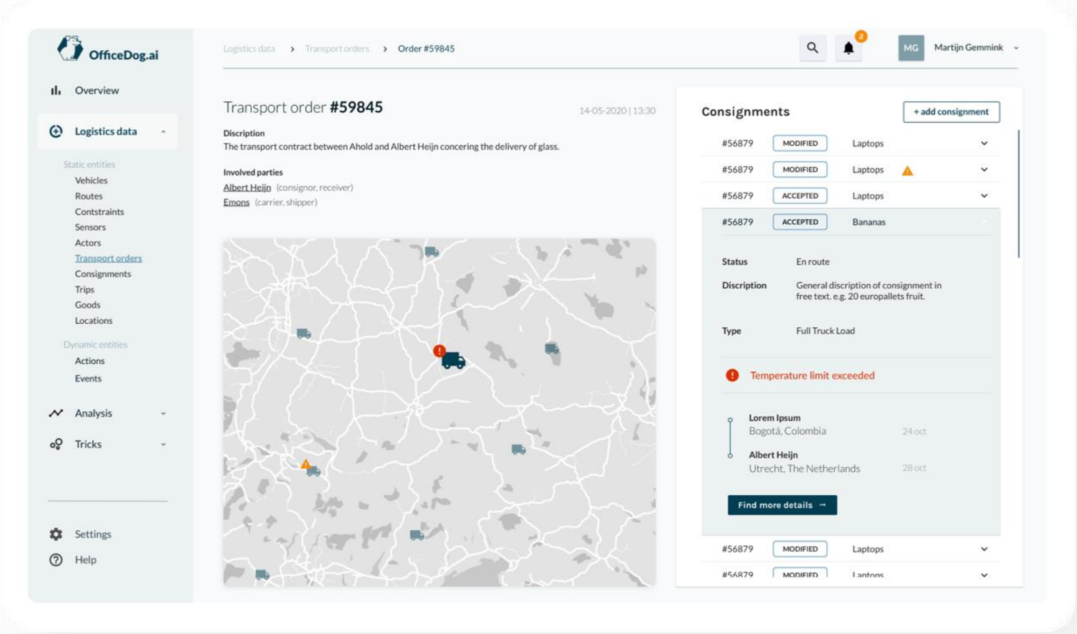
Transport orders

Showing 4.563 orders

Sort by: Most recent

Code	Data	Consignment	From/to	
342352	05/02/2021	Bananas	Columbia - Netherlands	More information
667856	02/04/2021	Laptops	Paris - Netherlands	More information
667856	05/02/2021	Bananas	Columbia - Netherlands	More information
342352	02/04/2021	Laptops	Columbia - Netherlands	More information
667856	02/04/2021	Bananas	Paris - Netherlands	More information
342352	05/02/2021	Bananas	Columbia - Netherlands	More information
342352	05/02/2021	Laptops	Columbia - Netherlands	More information
667856	02/04/2021	Bananas	Paris - Netherlands	More information
342352	02/04/2021	Laptops	Columbia - Netherlands	More information
667856	05/02/2021	Laptops	Paris - Netherlands	More information
667856	05/02/2021	Bananas	Columbia - Netherlands	More information

Figure 68: Mock-up for transport order data overview.



Transport order **#59845**

14-05-2020 | 13:30

Discription
The transport contract between Ahold and Albert Heijn concering the delivery of glass.

Involved parties
Albert Heijn (consignor, receiver)
Emons (carrier, shipper)

Consignments

#56879	MODIFIED	Laptops
#56879	MODIFIED	Laptops
#56879	ACCEPTED	Laptops
#56879	ACCEPTED	Bananas

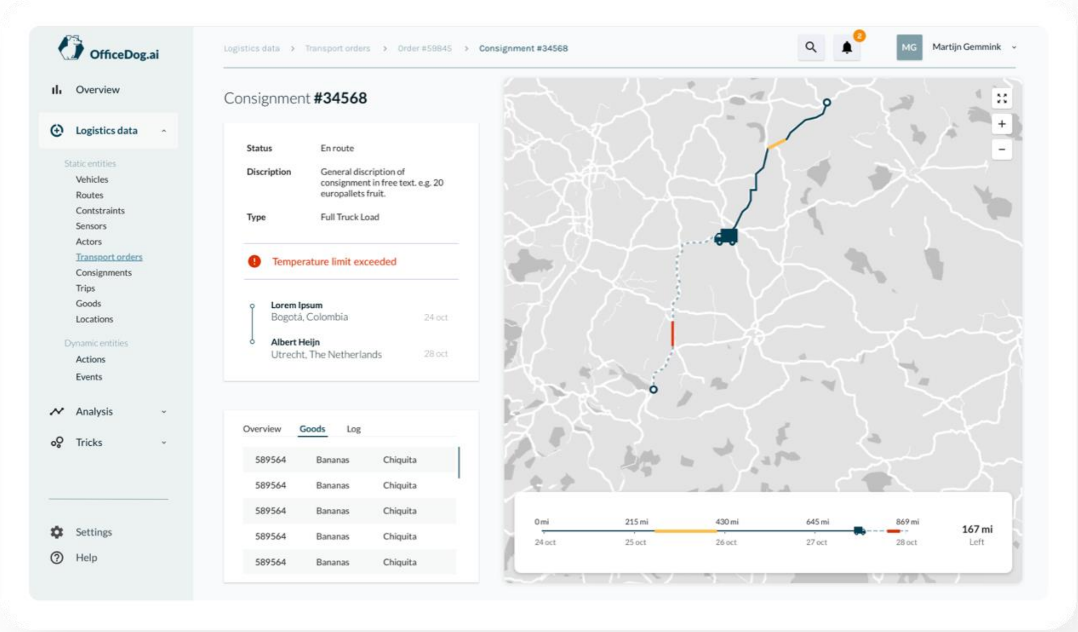
Status	En route
Discription	General discription of consignment in free text. e.g. 20 europallets fruit.
Type	Full Truck Load

Temperature limit exceeded

Lorem Ipsum
Bogotá, Colombia 24 oct
Albert Heijn
Utrecht, The Netherlands 28 oct

#56879	MODIFIED	Laptops
#56879	MODIFIED	Laptops

Figure 69: Mock-up for real-time traceability and condition monitoring.



Consignment **#34568**

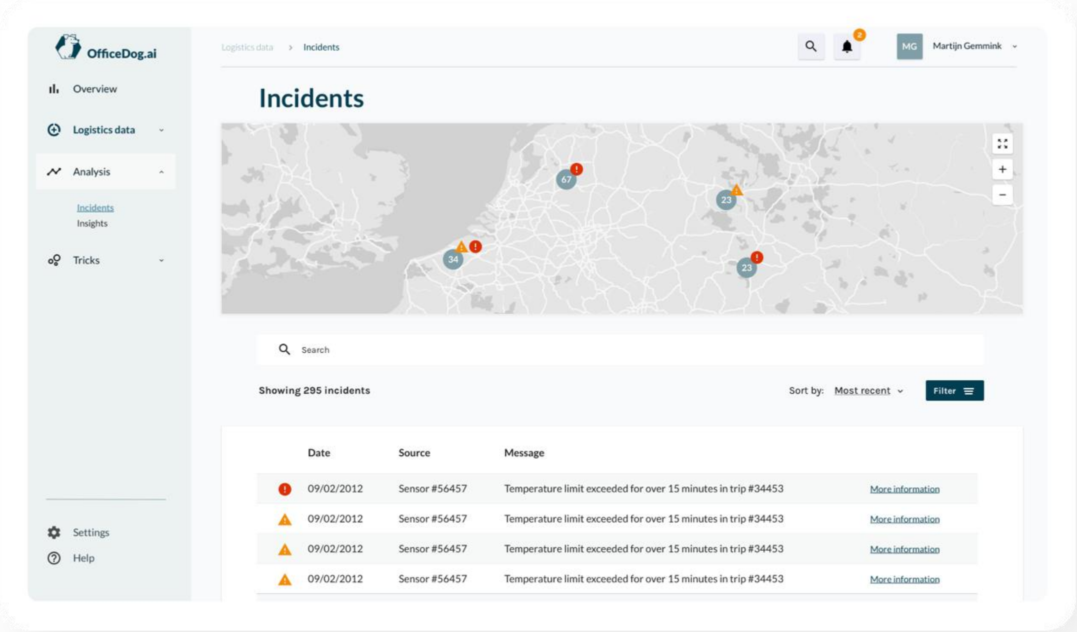
Status	En route
Discription	General discription of consignment in free text. e.g. 20 europallets fruit.
Type	Full Truck Load

Temperature limit exceeded

Lorem Ipsum
Bogotá, Colombia 24 oct
Albert Heijn
Utrecht, The Netherlands 28 oct

589564	Bananas	Chiquita
589564	Bananas	Chiquita
589564	Bananas	Chiquita
589564	Bananas	Chiquita
589564	Bananas	Chiquita

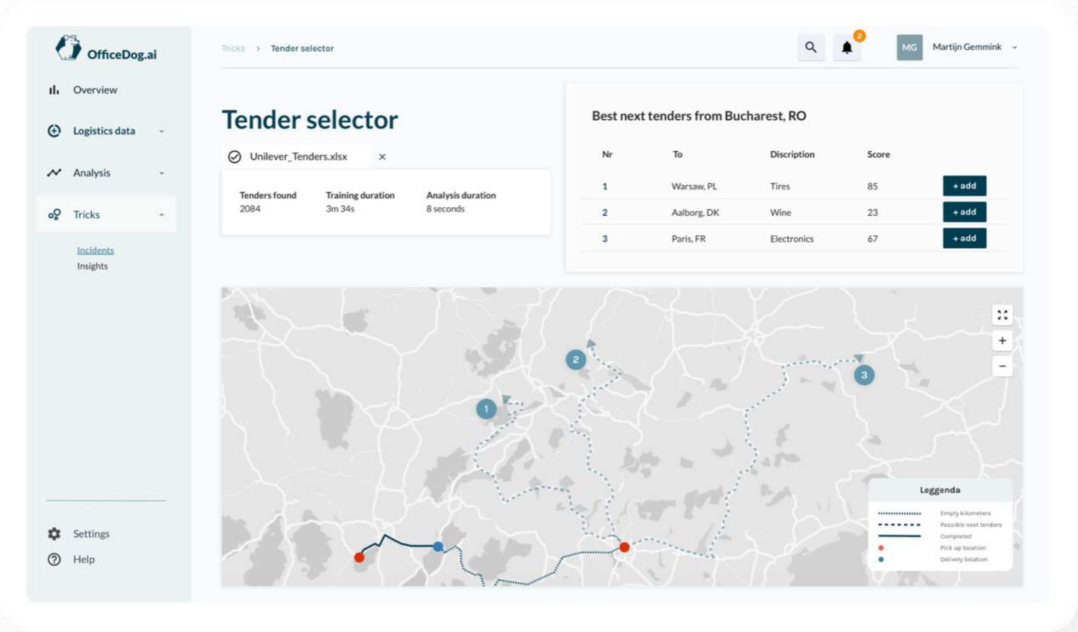
Figure 70: Mock-up of consignment data for track and trace.



Showing 295 incidents

	Date	Source	Message	
!	09/02/2012	Sensor #56457	Temperature limit exceeded for over 15 minutes in trip #34453	More information
⚠	09/02/2012	Sensor #56457	Temperature limit exceeded for over 15 minutes in trip #34453	More information
⚠	09/02/2012	Sensor #56457	Temperature limit exceeded for over 15 minutes in trip #34453	More information
⚠	09/02/2012	Sensor #56457	Temperature limit exceeded for over 15 minutes in trip #34453	More information

Figure 71: Mock-up for incident monitoring.



Tenders found	Training duration	Analysis duration
2084	3m 34s	8 seconds

Best next tenders from Bucharest, RO

Nr	To	Discription	Score	
1	Warsaw, PL	Tires	85	+ add
2	Aalborg, DK	Wine	23	+ add
3	Paris, FR	Electronics	67	+ add

Figure 72: Mock-up for tender selector.

I. Integration test input and results

The following sample Transport Order request body was supplied for the SUTC workshop:

```
J. {
     "id": "946e8aec-9ebc-4ea1-ad4f-c3784f05a7fa",
     "name": "TEST-TERRY-000002",
     "externalAttributes": {
       "id": "TEST-TERRY-000002"
     },
     "creationDate": "2021-11-24T15:18:28.901Z",
     "consignments": [
       {
         "entity": {
           "id": "3a697d4a-10c6-4bef-8eb2-c3ef4934259c",
           "name": "TEST-TERRY-000002",
           "creationDate": "2021-11-24T15:18:28.901Z",
           "status": "requested",
           "type": "BookedManually",
           "goods": [
             {
               "entity": {
                 "description": "TEST-TERRY-000002",
                 "quantity": 1,
                 "weight": {
                   "value": 50,
                   "unit": "kg"
                 },
                 "width": {
                   "value": 100,
                   "unit": "cm"
                 },
                 "height": {
                   "value": 50,
                   "unit": "cm"
                 },
                 "length": {
                   "value": 120,
                   "unit": "cm"
                 },
                 "packagingMaterial": "Blokpallet",
                 "type": "items"
               },
               "associationType": "inline"
             }
           ],
           "remark": "TEST-TERRY-000002",
           "actors": [
             {
               "entity": {
                 "id": "d5eb5217-935a-2438-a071-05f8fc9012e0",
                 "name": "Terry",
                 "creationDate": "2021-11-24T15:18:28.906Z",
                 "contactDetails": [
                   {
                     "value": "tdieckmann@voict.nl",
                     "type": "email"
                   },
                   {
                     "value": "+31 6 12455487",
                     "type": "phone"
                   },
```

```
                      {
                        "value": "Terry",
                        "type": "name"
                      }
                    ],
                    "locations": [
                      {
                        "entity": {
                          "id": "d5eb5217-935a-2438-a071-05f8fc9012e0",
                          "geoReference": {
                            "name": "Terry",
                            "street": "Halderweg",
                            "houseNumber": "95",
                            "postalCode": "6721ZJ",
                            "city": "Bennekom",
                            "country": "NL",
                            "type": "addressGeoReference"
                          },
                          "type": "customer"
                        },
                        "associationType": "inline"
                      }
                    ]
                  },
                  "roles": [
                    "consignor"
                  ],
                  "associationType": "inline"
                },
                {
                  "entity": {
                    "id": "96759bc9-3ff2-c3b6-7398-9e9086ff7529",
                    "name": "VOICT Maarssen",
                    "creationDate": "2021-11-24T15:18:28.908Z",
                    "contactDetails": [
                      {
                        "value": "tdieckmann@voict.nl",
                        "type": "email"
                      },
                      {
                        "value": "+31 6 12922348",
                        "type": "phone"
                      },
                      {
                        "value": "Terry",
                        "type": "name"
                      }
                    ],
                    "locations": [
                      {
                        "entity": {
                          "id": "96759bc9-3ff2-c3b6-7398-9e9086ff7529",
                          "geoReference": {
                            "name": "VOICT Maarssen",
                            "street": "Piet Heinstraat",
                            "houseNumber": "31",
                            "postalCode": "3601TE",
                            "city": "Maarssen",
                            "country": "NL",
                            "type": "addressGeoReference"
                          },
                          "type": "customer"
```

```
                        },
                        "associationType": "inline"
                      }
                    ]
                  },
                  "roles": [
                    "consignee"
                  ],
                  "associationType": "inline"
                },
                {
                  "entity": {
                    "id": "bfd4cafa-6aae-4c4c-b962-32c7c5497148",
                    "name": "VTS",
                    "contactDetails": [
                      {
                        "value": "",
                        "type": "email"
                      },
                      {
                        "value": "",
                        "type": "phone"
                      },
                      {
                        "value": "",
                        "type": "mobilePhone"
                      }
                    ]
                  },
                  "roles": [
                    "carrier"
                  ],
                  "associationType": "inline"
                },
                {
                  "entity": {
                    "id": "a8b78fea-860e-4e2e-af15-fc09be02ba3f",
                    "name": "Verlader",
                    "locations": [
                      {
                        "entity": {
                          "name": "Verlader",
                          "geoReference": {
                            "name": "Verlader",
                            "street": "Keesomstraat",
                            "houseNumber": "19",
                            "postalCode": "6717AH",
                            "city": "Ede",
                            "country": "NL",
                            "type": "addressGeoReference"
                          }
                        },
                        "associationType": "inline"
                      }
                    ]
                  },
                  "roles": [
                    "shipper"
                  ],
                  "associationType": "inline"
                }
              ],
```

```
        "actions": [
          {
            "entity": {
              "lifecycle": "planned",
              "location": {
                "entity": {
                  "id": "d5eb5217-935a-2438-a071-05f8fc9012e0",
                  "geoReference": {
                    "name": "Terry",
                    "street": "Halderweg",
                    "houseNumber": "95",
                    "postalCode": "6721ZJ",
                    "city": "Bennekom",
                    "country": "NL",
                    "type": "addressGeoReference"
                  },
                  "type": "customer"
                },
                "associationType": "inline"
              },
              "startTime": "2021-11-25T07:00:00Z",
              "endTime": "2021-11-25T16:00:00Z",
              "actionType": "load"
            },
            "associationType": "inline"
          },
          {
            "entity": {
              "lifecycle": "planned",
              "location": {
                "entity": {
                  "id": "96759bc9-3ff2-c3b6-7398-9e9086ff7529",
                  "geoReference": {
                    "name": "VOICT Maarssen",
                    "street": "Piet Heinstraat",
                    "houseNumber": "31",
                    "postalCode": "3601TE",
                    "city": "Maarssen",
                    "country": "NL",
                    "type": "addressGeoReference"
                  },
                  "type": "customer"
                },
                "associationType": "inline"
              },
              "actionType": "unload"
            },
            "associationType": "inline"
          }
        ]
      },
      "associationType": "inline"
    }
  ]
}
```

K.

Integration response from the industry platform's API:

```
{
    "status": 400,
    "message": [
        "consignmentAssociations.0.entityType must be a valid enum
value",
        "consignmentAssociations.0.entity.goodsAssociations.0.enti-
tyType must be a valid enum value",
        "consignmentAssociations.0.entity.actorAssociations.0.enti-
tyType must be a valid enum value",
        "consignmentAssociations.0.entity.actorAssociations.0.en-
tity.locationAssociations.0.entityType must be a valid enum value",
        "consignmentAssociations.0.entity.actorAssociations.1.enti-
tyType must be a valid enum value",
        "consignmentAssociations.0.entity.actorAssociations.1.en-
tity.locationAssociations.0.entityType must be a valid enum value",
        "consignmentAssociations.0.entity.actorAssociations.2.enti-
tyType must be a valid enum value",
        "consignmentAssociations.0.entity.actorAssociations.2.en-
tity.contactDetails.2.type must be one of the following values: other,
iban, gln, vatCode, name, lastName, middleName, firstName, email,
phone",
        "consignmentAssociations.0.entity.actorAssociations.3.enti-
tyType must be a valid enum value",
        "consignmentAssociations.0.entity.actorAssociations.3.en-
tity.locationAssociations.0.entityType must be a valid enum value",
        "consignmentAssociations.0.entity.actionAssociations.0.enti-
tyType must be a valid enum value",
        "consignmentAssociations.0.entity.actionAssociations.0.en-
tity.locationAssociation.entityType must be a valid enum value",
        "consignmentAssociations.0.entity.actionAssociations.1.enti-
tyType must be a valid enum value",
        "consignmentAssociations.0.entity.actionAssociations.1.en-
tity.locationAssociation.entityType must be a valid enum value"
    ],
    "timestamp": "2022-03-18T13:37:27.110Z",
    "path": "/transportOrders"
}
```

Integration test analysis:

```
{
  "id": "946e8aec-9ebc-4ea1-ad4f-c3784f05a7fa",
  "name": "TEST-TERRY-000002",
  "externalAttributes": {
    "id": "TEST-TERRY-000002"
  },
  "creationDate": "2021-11-24T15:18:28.901Z",
  "consignments": [
    {
      "entityType": "consignment",
      "entity": {
        "id": "3a697d4a-10c6-4bef-8eb2-c3ef4934259c",
        "name": "TEST-TERRY-000002",
        "creationDate": "2021-11-24T15:18:28.901Z",
        "status": "requested",
```

```
    "type": "BookedManually",
    "goods": [
      {
        "entityType": "goods",
        "entity": {
          "description": "TEST-TERRY-000002",
          "quantity": 1,
          "weight": {
            "value": 50,
            "unit": "kg"
          },
          "width": {
            "value": 100,
            "unit": "cm"
          },
          "height": {
            "value": 50,
            "unit": "cm"
          },
          "length": {
            "value": 120,
            "unit": "cm"
          },
          "packagingMaterial":  "Blokpallet",
          "type": "items"
        },
        "associationType": "inline"
      }
    ],
    "remark": "TEST-TERRY-000002",
    "actors": [
      {
        "entityType": "actor",
        "entity": {
          "id": "d5eb5217-935a-2438-a071-05f8fc9012e0",
          "name": "Terry",
          "creationDate": "2021-11-24T15:18:28.906Z",
          "contactDetails": [
            {
              "value": "tdieckmann@voict.nl",
              "type": "email"
            },
            {
              "value": "+31 6 12455487",
              "type": "phone"
            },
            {
              "value": "Terry",
```

```
          "type": "name"
        }
      ],
      "locations": [
        {
          "entityType": "location",
          "entity": {
            "id": "d5eb5217-935a-2438-a071-05f8fc9012e0",
            "geoReference": {
              "name": "Terry",
              "street": "Halderweg",
              "houseNumber": "95",
              "postalCode": "6721ZJ",
              "city": "Bennekom",
              "country": "NL",
              "type": "addressGeoReference"
            },
            "type": "customer"
          },
          "associationType": "inline"
        }
      ]
    },
    "roles": [
      "consignor"
    ],
    "associationType": "inline"
  },
  {
    "entityType": "actor",
    "entity": {
      "id": "96759bc9-3ff2-c3b6-7398-9e9086ff7529",
      "name": "VOICT Maarssen",
      "creationDate": "2021-11-24T15:18:28.908Z",
      "contactDetails": [
        {
          "value": "tdieckmann@voict.nl",
          "type": "email"
        },
        {
          "value": "+31 6 12922348",
          "type": "phone"
        },
        {
          "value": "Terry",
          "type": "name"
        }
      ],
```

```
    "locations": [
      {
        "entityType": "location",
        "entity": {
          "id": "96759bc9-3ff2-c3b6-7398-9e9086ff7529",
          "geoReference": {
            "name": "VOICT Maarssen",
            "street": "Piet Heinstraat",
            "houseNumber": "31",
            "postalCode": "3601TE",
            "city": "Maarssen",
            "country": "NL",
            "type": "addressGeoReference"
          },
          "type": "customer"
        },
        "associationType": "inline"
      }
    ]
  },
  "roles": [
    "consignee"
  ],
  "associationType": "inline"
},
{
  "entityType": "actor",
  "entity": {
    "id": "bfd4cafa-6aae-4c4c-b962-32c7c5497148",
    "name": "VTS",
    "contactDetails": [
      {
        "value": "",
        "type": "email"
      },
      {
        "value": "",
        "type": "phone"
      ~~},~~
      ~~{~~
        ~~"value": "",~~
        ~~"type": "mobilePhone"~~
      }
    ]
  },
  "roles": [
    "carrier"
  ],
```

```
      "associationType": "inline"
     },
     {
      "entityType":"actor",
      "entity":{
       "id": "a8b78fea-860e-4e2e-af15-fc09be02ba3f",
       "name": "Verlader",
       "locations": [
        {
         "entityType": "location",
         "entity":{
          "name": "Verlader",
          "geoReference":{
           "name": "Verlader",
           "street":"Keesomstraat",
           "houseNumber":"19",
           "postalCode": "6717AH",
           "city": "Ede",
           "country": "NL",
           "type":"addressGeoReference"
          }
         },
         "associationType": "inline"
        }
       ]
      },
      "roles": [
       "shipper"
      ],
      "associationType": "inline"
     }
    ],
    "actions": [
     {
      "entityType":"action",
      "entity":{
       "lifecycle": "planned",
       "location": {
        "entityType": "location",
        "entity":{
         "id": "d5eb5217-935a-2438-a071-05f8fc9012e0",
         "geoReference":{
          "name": "Terry",
          "street":"Halderweg",
          "houseNumber":"95",
          "postalCode": "6721ZJ",
          "city": "Bennekom",
          "country": "NL",
```

```
                    "type":"addressGeoReference"
                  },
                  "type": "customer"
                },
                "associationType": "inline"
              },
              "startTime": "2021-11-25T07:00:00Z",
              "endTime": "2021-11-25T16:00:00Z",
              "actionType": "load"
            },
            "associationType": "inline"
          },
          {
            "entityType":"action",
            "entity":{
              "lifecycle": "planned",
              "location": {
                "entityType": "location",
                "entity":{
                  "id": "96759bc9-3ff2-c3b6-7398-9e9086ff7529",
                  "geoReference":{
                    "name": "VOICT Maarssen",
                    "street":"Piet Heinstraat",
                    "houseNumber":"31",
                    "postalCode": "3601TE",
                    "city": "Maarssen",
                    "country": "NL",
                    "type":"addressGeoReference"
                  },
                  "type": "customer"
                },
                "associationType": "inline"
              },
              "actionType": "unload"
            },
            "associationType": "inline"
          }
        ]
      },
      "associationType": "inline"
    }
  ]
}
```

Second integration test request:

```
{
  "id": "946e8aec-9ebc-4ea1-ad4f-c3784f05a7fa",
```

```
    "name": "TEST-TERRY-000002",
    "externalAttributes": {
      "id": "TEST-TERRY-000002"
    },
    "creationDate": "2021-11-24T15:18:28.901Z",
    "consignments": [
      {
        "entityType": "consignment",
        "entity": {
          "id": "3a697d4a-10c6-4bef-8eb2-c3ef4934259c",
          "name": "TEST-TERRY-000002",
          "creationDate": "2021-11-24T15:18:28.901Z",
          "status": "requested",
          "type": "BookedManually",
          "goods": [
            {
              "entityType": "goods",
              "entity": {
                "description": "TEST-TERRY-000002",
                "quantity": 1,
                "weight": {
                  "value": 50,
                  "unit": "kg"
                },
                "width": {
                  "value": 100,
                  "unit": "cm"
                },
                "height": {
                  "value": 50,
                  "unit": "cm"
                },
                "length": {
                  "value": 120,
                  "unit": "cm"
                },
                "packagingMaterial": "Blokpallet",
                "type": "items"
              },
              "associationType": "inline"
            }
          ],
          "remark": "TEST-TERRY-000002",
          "actors": [
            {
              "entityType": "actor",
              "entity": {
                "id": "d5eb5217-935a-2438-a071-05f8fc9012e0",
                "name": "Terry",
                "creationDate": "2021-11-24T15:18:28.906Z",
                "contactDetails": [
                  {
                    "value": "tdieckmann@voict.nl",
                    "type": "email"
                  },
                  {
                    "value": "+31 6 12455487",
                    "type": "phone"
                  },
                  {
                    "value": "Terry",
                    "type": "name"
```

```
                }
              ],
              "locations": [
                {
                  "entityType": "location",
                  "entity": {
                    "id": "d5eb5217-935a-2438-a071-05f8fc9012e0",
                    "geoReference": {
                      "name": "Terry",
                      "street": "Halderweg",
                      "houseNumber": "95",
                      "postalCode": "6721ZJ",
                      "city": "Bennekom",
                      "country": "NL",
                      "type": "addressGeoReference"
                    },
                    "type": "customer"
                  },
                  "associationType": "inline"
                }
              ]
            },
            "roles": [
              "consignor"
            ],
            "associationType": "inline"
          },
          {
            "entityType": "actor",
            "entity": {
              "id": "96759bc9-3ff2-c3b6-7398-9e9086ff7529",
              "name": "VOICT Maarssen",
              "creationDate": "2021-11-24T15:18:28.908Z",
              "contactDetails": [
                {
                  "value": "tdieckmann@voict.nl",
                  "type": "email"
                },
                {
                  "value": "+31 6 12922348",
                  "type": "phone"
                },
                {
                  "value": "Terry",
                  "type": "name"
                }
              ],
              "locations": [
                {
                  "entityType": "location",
                  "entity": {
                    "id": "96759bc9-3ff2-c3b6-7398-9e9086ff7529",
                    "geoReference": {
                      "name": "VOICT Maarssen",
                      "street": "Piet Heinstraat",
                      "houseNumber": "31",
                      "postalCode": "3601TE",
                      "city": "Maarssen",
                      "country": "NL",
                      "type": "addressGeoReference"
                    },
                    "type": "customer"
```

```
                  },
                  "associationType": "inline"
                }
              ]
            },
            "roles": [
              "consignee"
            ],
            "associationType": "inline"
          },
          {
            "entityType": "actor",
            "entity": {
              "id": "bfd4cafa-6aae-4c4c-b962-32c7c5497148",
              "name": "VTS",
              "contactDetails": [
                {
                  "value": "",
                  "type": "email"
                },
                {
                  "value": "",
                  "type": "phone"
                }
              ]
            },
            "roles": [
              "carrier"
            ],
            "associationType": "inline"
          },
          {
            "entityType": "actor",
            "entity": {
              "id": "a8b78fea-860e-4e2e-af15-fc09be02ba3f",
              "name": "Verlader",
              "locations": [
                {
                  "entityType": "location",
                  "entity": {
                    "name": "Verlader",
                    "geoReference": {
                      "name": "Verlader",
                      "street": "Keesomstraat",
                      "houseNumber": "19",
                      "postalCode": "6717AH",
                      "city": "Ede",
                      "country": "NL",
                      "type": "addressGeoReference"
                    }
                  },
                  "associationType": "inline"
                }
              ]
            },
            "roles": [
              "shipper"
            ],
            "associationType": "inline"
          }
        ],
        "actions": [
```

```
          {
            "entityType": "action",
            "entity": {
              "lifecycle": "planned",
              "location": {
                "entityType": "location",
                "entity": {
                  "id": "d5eb5217-935a-2438-a071-05f8fc9012e0",
                  "geoReference": {
                    "name": "Terry",
                    "street": "Halderweg",
                    "houseNumber": "95",
                    "postalCode": "6721ZJ",
                    "city": "Bennekom",
                    "country": "NL",
                    "type": "addressGeoReference"
                  },
                  "type": "customer"
                },
                "associationType": "inline"
              },
              "startTime": "2021-11-25T07:00:00Z",
              "endTime": "2021-11-25T16:00:00Z",
              "actionType": "load"
            },
            "associationType": "inline"
          },
          {
            "entityType": "action",
            "entity": {
              "lifecycle": "planned",
              "location": {
                "entityType": "location",
                "entity": {
                  "id": "96759bc9-3ff2-c3b6-7398-9e9086ff7529",
                  "geoReference": {
                    "name": "VOICT Maarssen",
                    "street": "Piet Heinstraat",
                    "houseNumber": "31",
                    "postalCode": "3601TE",
                    "city": "Maarssen",
                    "country": "NL",
                    "type": "addressGeoReference"
                  },
                  "type": "customer"
                },
                "associationType": "inline"
              },
              "actionType": "unload"
            },
            "associationType": "inline"
          }
        ]
      },
      "associationType": "inline"
    }
  ]
}
```

J. Design workshop agenda (in Dutch) and evaluation

Workshop – Aan de slag met kunstmatige intelligentie in de logistiek

Datum – Donderdag 3 September 2020 – 09:00 – 17:00

Locatie – Emons, Milsbeek

Ruimte – Vergaderruimte met TV / wifi / whiteboard / flipover / stiften

Emons AI canvas geprint op A3

Facilitators:

- Sebastian Piest (Universiteit Twente) – onderzoeker
- Martijn Gemmink (Bullit Digital) – eigenaar

Genodigden:

- Gerard Alders – eindverantwoordelijk Emons Service Center, heeft uitgenodigd:
    - Thomas Massop – Business & Process Analyst
    - Kevin Lemmers – Business & Process Analyst
- Marcel Wouterse – eindverantwoordelijk Emons Cargo
- Gewenst: Daan Emons (begin / einde dag) – eigenaar Emons

Doel workshop:

- Overzicht genereren toepassingsmogelijkheden van kunstmatige intelligentie binnen Emons
- Conceptualiseren ideeën in AI canvas
- Concretiseren pilot

Globale opzet workshop:

- Ochtend – inspireren en brainstormen
- Middag – conceptualiseren en concretiseren

Tijdsplanning:

09:00 – 09:30	Ontvangst en kennismaking Emons en aanwezigen
09:30 – 10:45	Interactieve presentatie en demo door Sebastian en Martijn
10:45 – 11:00	Break
11:00 – 12:30	Brainstorm: ideeën, toepassingen, voorbeelden, vragen, concerns
12:30 – 13:30	Lunch
13:30 – 14:00	Toelichting en voorbeeld AI canvas door Sebastian en Martijn
14:00 – 15:30	Workshop: uitwerken 3-5 canvassen
15:30 – 15:45	Break
15:45 – 16:00	Pitchen canvassen
16:00 – 17:00	Concretiseren pilot / samenwerkingsafspraken

Workshop evaluation

Table 38 presents the workshop evaluation scores and feedback.

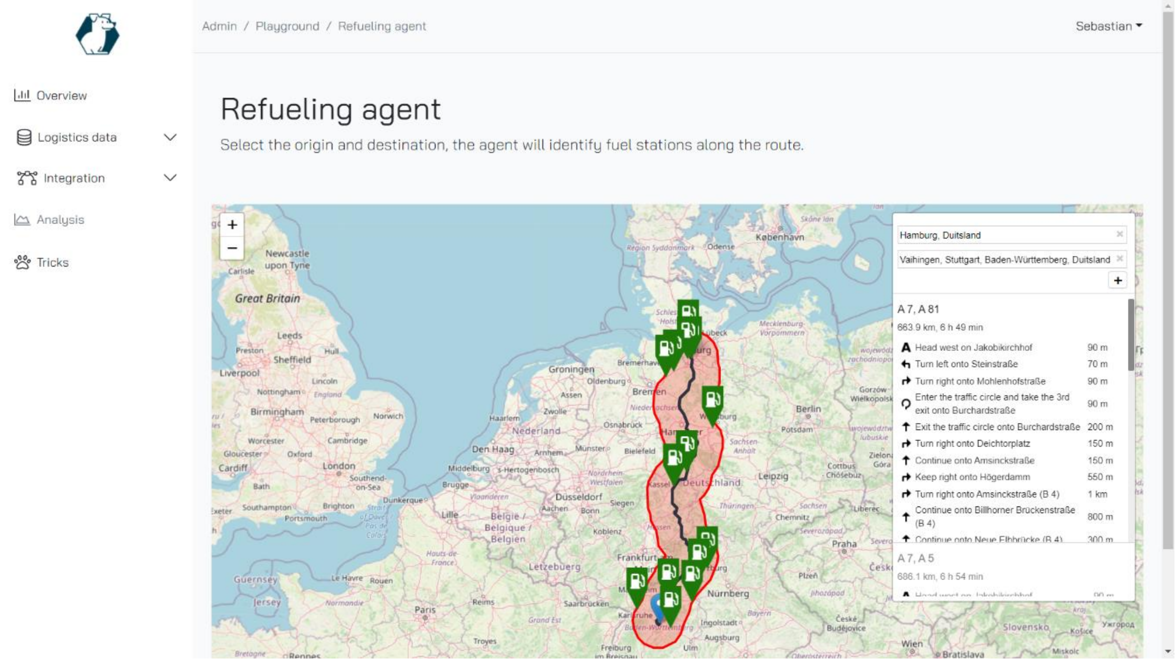
Evaluation	Criteria	Score					Feedback for improvement
		1	2	3	4	5	
Design canvas	Eases requirements gathering process					■	Forces thinking in multiple dimensions
						■	Thinking in building blocks, add examples
						■	Add more logic in blocks and design patterns
					■	■	KPI examples, when are you done?
	Facilitates communication				■		Create mutual understanding, can be complex
					■		Efforts and feasibility check can be added
						■	Supports better understanding, no action
						■	Good discussion instrument, many aspects
	Stimulates acting		■				Supports first step, not implementation
			■				Creates overview, no action
		■					Business case elements are missing
			■				Stimulates thinking, no next steps
Workshop	Supports ideation process				■		Supports brainstorming, also unrealistic ideas
					■		Contributes to understanding
					■		Position flow from awareness-alignment-action
					■		Supports brainstorm-ideas-concept
	Supports conceptualization and design process			■	■		Cluster ideas in functions, check existing tools
					■		Dependent on group dynamics
					■		Keep in mind the backgrounds
					■		Add first check on process and data maturity

Table 38: Design canvas workshop evaluation and feedback.

K. Results of the industry platform use and refuelling agent

Figure 73-75 show the results of the refuelling agent. **Table 39 and 40** contain the evaluation of the industry platform and refuelling agent.

Repeating trade lane Hamburg - Vaihingen



Admin / Playground / Refueling agent

Refueling agent

Select the origin and destination, the agent will identify fuel stations along the route.

Hamburg, Duitsland

Vaihingen, Stuttgart, Baden-Württemberg, Duitsland

A 7, A 81

663.9 km, 6 h 49 min

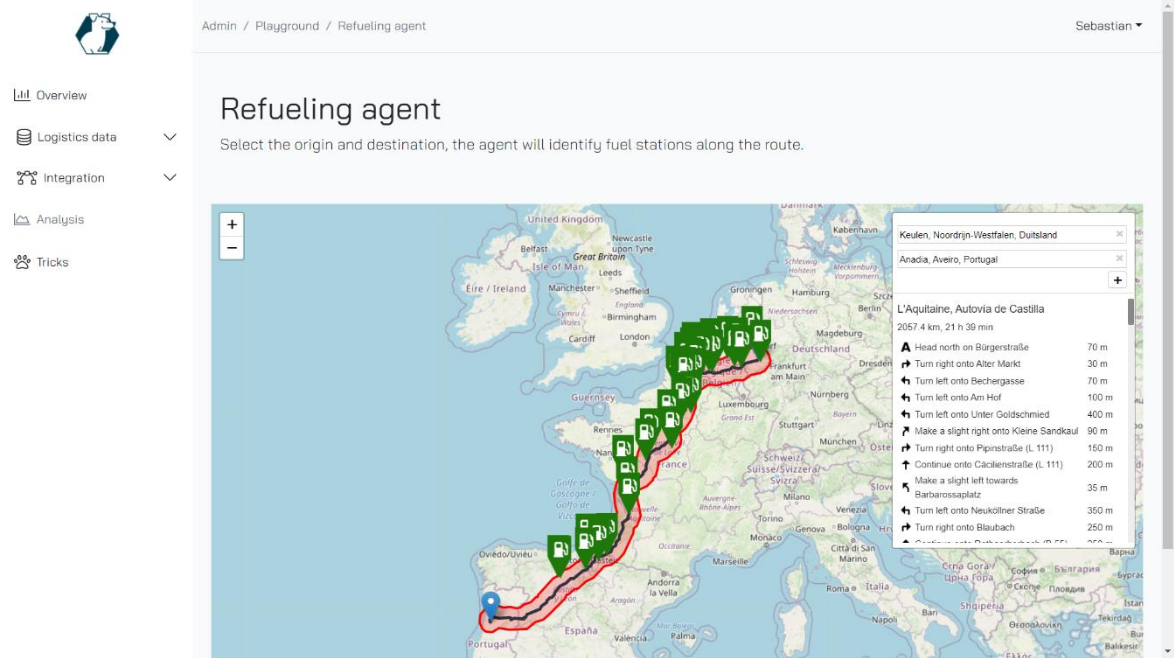
Head west on Jakobikirchhof	90 m
Turn left onto Steinstraße	70 m
Turn right onto Mohlenhofstraße	90 m
Enter the traffic circle and take the 3rd exit onto Burchardstraße	90 m
Exit the traffic circle onto Burchardstraße	200 m
Turn right onto Deichtorplatz	150 m
Continue onto Amsinckstraße	150 m
Keep right onto Högerdamm	550 m
Turn right onto Amsinckstraße (B 4)	1 km
Continue onto Billhorner Brückenstraße (B 4)	800 m
Continue onto Neue Elbbrücke (B 4)	300 m

A 7, A 5

686.1 km, 6 h 54 min

Figure 73: Screenshot of refuelling agent results for repeating trade lane Hamburg - Vaihingen.

Repeating trade lane Köln - Anadia



Admin / Playground / Refueling agent

Refueling agent

Select the origin and destination, the agent will identify fuel stations along the route.

Keulen, Noordrijn-Westfalen, Duitsland

Anadia, Aveiro, Portugal

L'Aquitaine, Autovia de Castilla

2057.4 km, 21 h 39 min

Head north on Bürgerstraße	70 m
Turn right onto Alter Markt	30 m
Turn left onto Bechergasse	70 m
Turn left onto Am Hof	100 m
Turn left onto Unter Goldschmied	400 m
Make a slight right onto Kleine Sandkaul	90 m
Turn right onto Pipinstraße (L 111)	150 m
Continue onto Cäcilienstraße (L 111)	200 m
Make a slight left towards Barbarossaplatz	35 m
Turn left onto Neuköllner Straße	350 m
Turn right onto Blaubach	250 m

Figure 74: Screenshot of refuelling agent results for repeating trade lane Köln - Anadia.

Repeating trade lane Targau - Kjellerup

Refueling agent

Select the origin and destination, the agent will identify fuel stations along the route.

Torgau, Nordsachsen, Saksen, Duitsland

Kjellerup, Silkeborg Municipality, 8620, Denemarken

A 24, A 7

743.9 km, 8 h 26 min

Head southeast	35 m
Turn right onto Dahlener Straße	600 m
Turn left	450 m
Turn left onto S 24	100 m
Enter the traffic circle and take the 2nd exit onto B 182	80 m
Exit the traffic circle onto B 182	2 km
Go straight onto Friedrich-Naumann-Straße (B 182)	800 m
Make a slight right onto Dr.-Külz-Ufer (B 182)	200 m
Turn left onto Warschauer Straße (B 182)	800 m
Turn right onto Ludwig-Feuerbach-Straße	250 m

Figure 75: Screenshot of refuelling agent results for repeating trade lane Targau - Kjellerup.

Evaluation results – Industry Platform – Refuelling Agent

Requirement	ID	1	2	3	4	5	Comments
Enhance problem solving capabilities	1			▨			The current shown artefact will provide support for the operational employees. This is, to date, limited but could be extended. Displaying fuel stations only is already an improvement in the operational process. Additions need to be made for improved decision support.
	2			▨			Based on example data, some abstractions made i.e., distance from route
	3				▨		It is easier to identify fuel stations, apart from that no big implications.
	4				▨		Fast performance but need to explore and experiment with big data.
	5				▨		-
	6			▨			The platform (Office Dog) can import fuel locations from a sheet and display these on a map.
	7			▨			Only small part is automated of the fleet managers decision process, it provides a first selection of the fuel station. With that time to make decision is reduced a bit, but partly offset since it is not included/linked to the TMS. Hearing that this was a in between product that was set, then I would say score = 4 as it does what was requested except that its bird's eye view and not exact routing/timing (therefore no 5).
	8			▨			I believe that convincing industry experts about the accuracy of the proposed decisions might be a challenge. Think about providing more transparency to support the proposed 'optimal' decision and increase trust. Just as an idea, as the problems you are trying to model are quite complex and it might be hard (or nearly impossible) to include all real-life factors in the mathematical representation and find the real best decision, I would also consider providing a couple of possible decisions (e.g. top 3 based on their scores) with some characteristics (e.g. detour in km, price per litre, etc) and letting the experts in the field use the recommendations and their own experience to make the 'best' decision, instead of

				■			pointing out what the optimal decision is directly based on mathematics only.
(Partially) automate tasks related to decision-making	1			■			Showing the stations on the map will allow us to digitalise and replace the current excel file which are mailed to all actors/planners. If the decision support tool can be validated to provide pre-fuel decision support and post fuelling evaluation then a great leap forward could be made.
	2			■			Automated between input and output, but no automation after drawing route.
	3			■			Identifying fuel stations is automated, the user decides.
	4				■		Extract and load from Excel are fast.
	5					■	-
	6	■					At the moment there is not task automation for refuelling.
	7		■				Decisions are still mainly manual, small part is automated. Though not yet the fuel locations/timing suggestions that will change/improve the current decision-making. So the people’s expertise is in this version of the agent is still a black box in people’s minds and therefore not automated.
	8				■		See comment above.
Utility of the system in daily operation	1				■		Although not yet tested/used in the operation I expect it to be used daily and monthly for the evaluation of the driver and fleet manager’s fuel decision-making.
	2				■		Aligns with need for models.
	3			■			-
	4				■		The fast iteration works but need more refinement.
	5					■	-
	6	■					At the moment there is not task automation for refuelling.
	7	■					Not in operations yet.
	8				■		-
Ease of use of the system	1				■		I think the cost to on-board new user will be low and perhaps self-thought.
	2				■		Easy to use.
	3		■				No idea.
	4					■	Need training but easy to understand.
	5					■	-
	6			■			As far as I know the import of the data into the platform is easy. Part of the process is to export the data from the operational systems to the platform. This should be considered in the ease of use score.
	7			■			Ease of use of the system seems good what I could judge (demo of officedog) (score = 4). But embedding it in practice (so when to use it, interpretation etc), that I expect to take more time, but I think that’s not due to office dog, but due to change management and onboarding in general(score = 2).
	8				■		-
Time efficient in use	1			■			Viewing the stations on the map is a support but I cannot yet say anything of time savings.
	2				■		Quickly see results.
	3		■				More efficient when the agent makes some decisions.
	4					■	Its fast and consumes less time.
	5					■	-
	6	■					At the moment its not integrated into operational systems and does not provide extra information. So its extra work.
	7						Not operational yet so impossible to judge → no score. Not integrated with TMS. Therefore, additional steps required outside system.
	8				■		-

Non-invasive in use	1				▨		It looks like a very easy to use tool too some extend. I am uncertain about the cost to build, but I think it will soon make a positive ROI and certainly when decision support is added / extended.
	2		▨				Not configurable yet.
	3			▨			-
	4				▨		-
	5					▨	-
	6	▨					See comment on previous item. It is invasive because it is not integrated.
	7						?
	8				▨		-

Table 39: Evaluation form – scores.

Question	ID	Answers
What is your general impression of the platform and its functionality?	1	So far it has shown its potential. Functionality is quickly added so it seems / looks. The possibility to add new functionality and intelligence is promising.
	2	Nice first step, far to go still.
	3	-
	4	High potential.
	5	Its super user friendly.
	6	This evaluation is too early, as the platform is in development. I can see the strategic value eventually, as there is a conversion to a standard semantic model.
	7	The officedog platform looks like a promising platform taking into account the multiple ways to connect your data (which is good for SME's that have different sources and level of technologies and expertise). Next to that, OTM looks like it's going to play a key role in the near future for transparency throughout the chain and different control tower activities within (parts of) the supply chain. I haven't been able to work actively with it so far, but my understanding is that in the near future, organisations themselves can make their own tricks as well as "public" tricks can be used as in a sort of marketplace. This concept works already in certain areas, but specific in the area of transport, data, dashboarding and AI, I think this is not present yet but might get a lot of attention with office dog stepping in.
	8	Easy to use, user-friendly, nice design, appealing that a single tool might be leveraged to support multiple decision-making processes at a company, and they would not need to purchase multiple software (e.g., incurring less costs of training employees, increasing employee satisfaction etc).
What can be improved or added to the platform to increase its utility?	1	In many ways. I would like to see though that we can make it work for a few at a very high-level of practical usability.
	2	-
	3	-
	4	Data model suitable to Emons environment needs to be in place.
	5	Maybe you can also put some features for the different fuel stations (considering lambda parameters), f.e., distance and prices.
	6	The platform should replace part of the operational or tactical elements that are now part of other systems (sometimes excel sheets). This can be done if the platform requirement grows, and standard systems cannot cope with this.
	7	A bit more clarity what happens behind the scenes wrt OTM. It is a set of agreements, but how does officedog makes sure that this fit to transportation companies that have slightly different interpretation of data or have exotic areas in their data.
	8	I believe that providing some level of transparency regarding how the agent(s) made a certain recommendation might enhance the trust of the end-user in the platform. Taking the refuelling agent as an example, if I was an expert using the tool to support my decisions, I would like to see the consequences of sending a truck to the proposed gas station – e.g. detour in km, total driving time, price per litre, etc.

Table 40: Evaluation form - open-ended questions.

L. Evaluation data and forms of design canvas workshops

Table 41 and 42 contain the workshop evaluation data.

ID	Nr.	Grade	Recom-mend	Intake	Content	Theory-applica-tion	Stimulate thinking-acting	Teaching style	Inter-action
1	1	8	Yes	4	4	4	5	5	3
2	1	8	Yes	5	4	4	5	4	3
3	1	8	Yes		4	4	5	4	3
4	1	8	Yes	4	4	4	4	4	3
5	1	7,5	Yes		3	4	5	4	4
6	1	8	Yes	4	4	5	4	5	3
7	1	7	No	2	4	5	5	5	2
8	1	7,5	Yes	4	4	3	3,5	4	4
9	1	7	No	4	3	3	4	4	3
10	1	7	Yes	4	4	3	5	4	4
11	1	6,25	No		3	3	3	4	4
12	2	8	Yes	5	4	5	4	4	4
13	2	8	Yes	5	4	4	4	4	4
14	2	8	Yes	5	4	3	4	5	5
15	2	8	Yes		5	3	3	5	5
16	2	9	Yes		4	4	4	5	5
17	2	9	Yes	4	5	3	5	5	4
18	2	9	Yes	4	5	4	5	5	5
19	2	8	Yes	4	4	3,5	5	4	5
20	3	8	Yes	4	4	4	5	5	5
21	3	8	Yes	4	4	3	5	4	4
22	3	8	Yes	3	4	4	5	4	5
23	3	8	Yes	4	4	3	4	4	4
24	3	7	Yes	3	4	3	4	5	4
25	3	7	Yes	4	3	3	5	4	5

Table 41: Design canvas workshop evaluation data - scores.

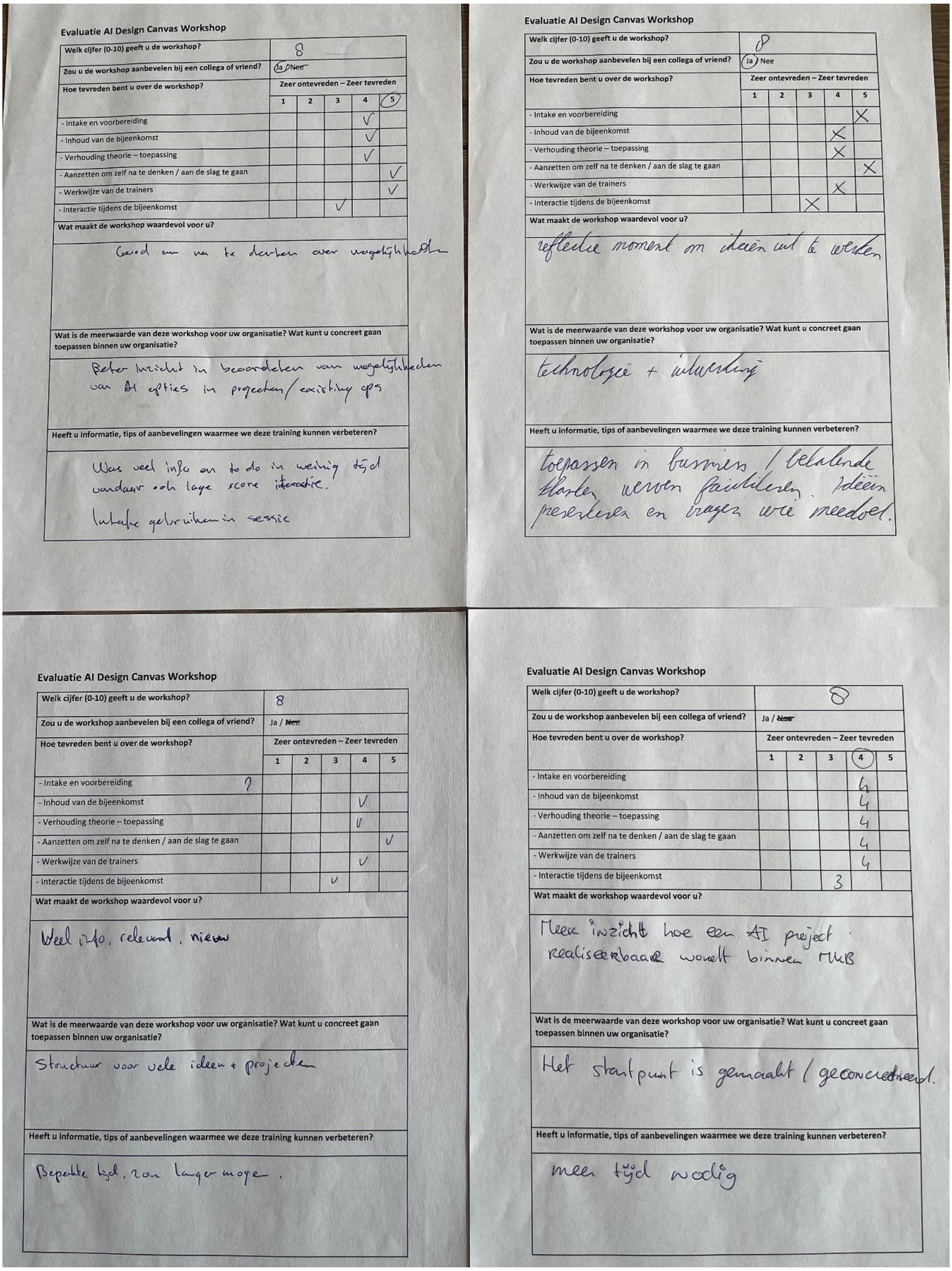
ID	What makes it valuable for you?	What is the added value for your organization?	Do you have information, suggestions that we can use to improve?
1	Good to think about possibilities	Better insight in assessment of possibilities of AI for projects and existing operations	A lot of information in short time, therefore low score on iteration, use intake in session
2	Reflection moment to work on ideas	Technology and conceptualization	Application in business, stimulate acquisition of customers, present ideas and ask who's in
3	A lot of information, relevant, new	Structure for many ideas and projects	Limited time, should be longer
4	Insight how AI project can be realized in SME	Starting point created, made concrete	More time required
5	Informative regarding applicability in logistics	Stimulates thinking about projects	Well done!
6	Contents	Self-learning/self-connecting algorithms	-

7	Insight in AI and how to start	Idea what we can do with AI and how to collaborate with LCB/DALI	Intake was not used during workshop to create interaction between groups
8	Integration AI in organization, set-up of design canvas	Realize improvements in WMS process optimalizations	More interaction between trainers-participants, more depth regarding AI implementation, 1 day programme, perhaps 2 days
9	Put thinking process on paper, discuss different ideas, awareness-align-act way of thinking is stimulated	Where to focus, where to begin, with whom	Not enough time to iterate canvas multiple times
10	Insight how to start with AI	Think more about AI applications	Take more time to discuss all contents
11	Additional way of thinking/variation to kaizen, yellow/green belt	-	-
12	Practical examples and think along with case of your own company	Background and learnings regarding AI trajectory, where to think about	Add more practical examples to presentation, more moments for interaction
13	Combi expert and experience decision-making	Change management aspects of new technology introduction	Broadening knowledge, e.g. whitepaper or video
14	Provides new insights, the trajectory to start a project and what is needed is very valuable	The role of project management and involving all employees in the organization, applying the design canvas for new projects	-
15	Nice to hear about experiences from other companies, and the many theories that are behind a 'simple' project	I want to apply the readiness model to get an 'honest' perspective where we stand	It was a lot of listening, try to balance theory with applying, then the contents stick better
16	The problems other participants rise, increasing knowledge, the printed posters	Large, my goal is to bring the AI movement further into the curriculum, this provides a starting point	Not really, add 2 other organizations, but if participants bring more problems that gives a completer perspective
17	Tangible result, increases insight and knowledge, practical model with example we can get started with	With the AI canvas we can start a discussion with stakeholders and involve software developers for realization and implementation	I would like to be coached on the job more when filling in the design canvas
18	Workshop is directly applicable in practice, trainers and participants give pleasant feedback; presentation helps to complete the design canvas in 3 iterations	The design canvas is directly applicable, and we expect within 3-4 months to make active use	Automate this form :)
19	Systematic thinking about AI with the patterns, review all aspects in-depth	Hard to make explicit, but abstract: knowledge of the 'parts' on the way to AI	Concrete examples for each aspect of the design canvas
20	Getting other insights in a project is very valuable for me to look differently to my	By means of this workshop we can get started and have a better insight who to involve in the	For me relevant examples are very useful, so providing even

	project. Additionally, it is valuable to spar about problems you can face in projects with others	project and how to provide feedback to the organization. Additionally, the explanation of the design canvas is useful for future projects.	more examples of concrete projects are pleasant
21	Making the concepts behind AI concrete. Give insight in the added value.	Knowlegde transfer. Convincing stakeholders.	-
22	Good interaction with a diversity of business cases that open your eyes	Diverse models that are applicable, good reference material	Share the business cases of others prior the workshop
23	Structured thinking about the design of AI projects, insights from other companies, examples how their problems can be solved	Constantly ask yourself the questions that were raised during the workshop to build structure	I was hoping for more practical knowledge regarding commonly used AI techniques for forecasting, roughly which model do you select and how to make this choice
24	Theory, canvas	Canvas, communication within company about AI projects	More examples from practice, actual use of algorithms/models, use cases from industry
25	New insights, look different at things	Getting started, methods for defining and setting up DS/ML/AI projects (canvas)	More structure <> do things on your own. Concrete examples, from theory supervised-unsupervised etc.

Table 42: Design canvas workshop evaluation data - open-ended questions.

L.1. 1st DALI Workshop



Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / ~~Nee~~				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	[✓ **5**]
- Intake en voorbereiding				✓	
- Inhoud van de bijeenkomst				✓	
- Verhouding theorie – toepassing				✓	
- Aanzetten om zelf na te denken / aan de slag te gaan					✓
- Werkwijze van de trainers					✓
- Interactie tijdens de bijeenkomst			✓		

Wat maakt de workshop waardevol voor u?

Goed om na te denken over mogelijkheden

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Beter inzicht in beoordelen van mogelijkheden van AI opties in projecten/existing ops

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Was veel info en to do in weinig tijd vandaar ook lage score interactie.

Intake gebruiken in sessie

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding					✗
- Inhoud van de bijeenkomst				✗	
- Verhouding theorie – toepassing				✗	
- Aanzetten om zelf na te denken / aan de slag te gaan					✗
- Werkwijze van de trainers				✗	
- Interactie tijdens de bijeenkomst			✗		

Wat maakt de workshop waardevol voor u?

reflectie moment om ideeën uit te werken

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

technologie + uitwerking

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

toepassen in business / betalende klanten werven faciliteren. Ideeën presenteren en vragen wie meedoet.

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja / ~~Nee~~				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding ?					
- Inhoud van de bijeenkomst				✓	
- Verhouding theorie – toepassing				✓	
- Aanzetten om zelf na te denken / aan de slag te gaan					✓
- Werkwijze van de trainers				✓	
- Interactie tijdens de bijeenkomst			✓		

Wat maakt de workshop waardevol voor u?

Veel info, relevant, nieuw

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Structuur voor vele ideeen + projecten

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Beperkte tijd, zou langer mogen.

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja / ~~Nee~~				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	[✓ **4**]	**5**
- Intake en voorbereiding				4	
- Inhoud van de bijeenkomst				4	
- Verhouding theorie – toepassing				4	
- Aanzetten om zelf na te denken / aan de slag te gaan				4	
- Werkwijze van de trainers				4	
- Interactie tijdens de bijeenkomst			3		

Wat maakt de workshop waardevol voor u?

Meer inzicht hoe een AI project realiseerbaar wordt binnen MKB

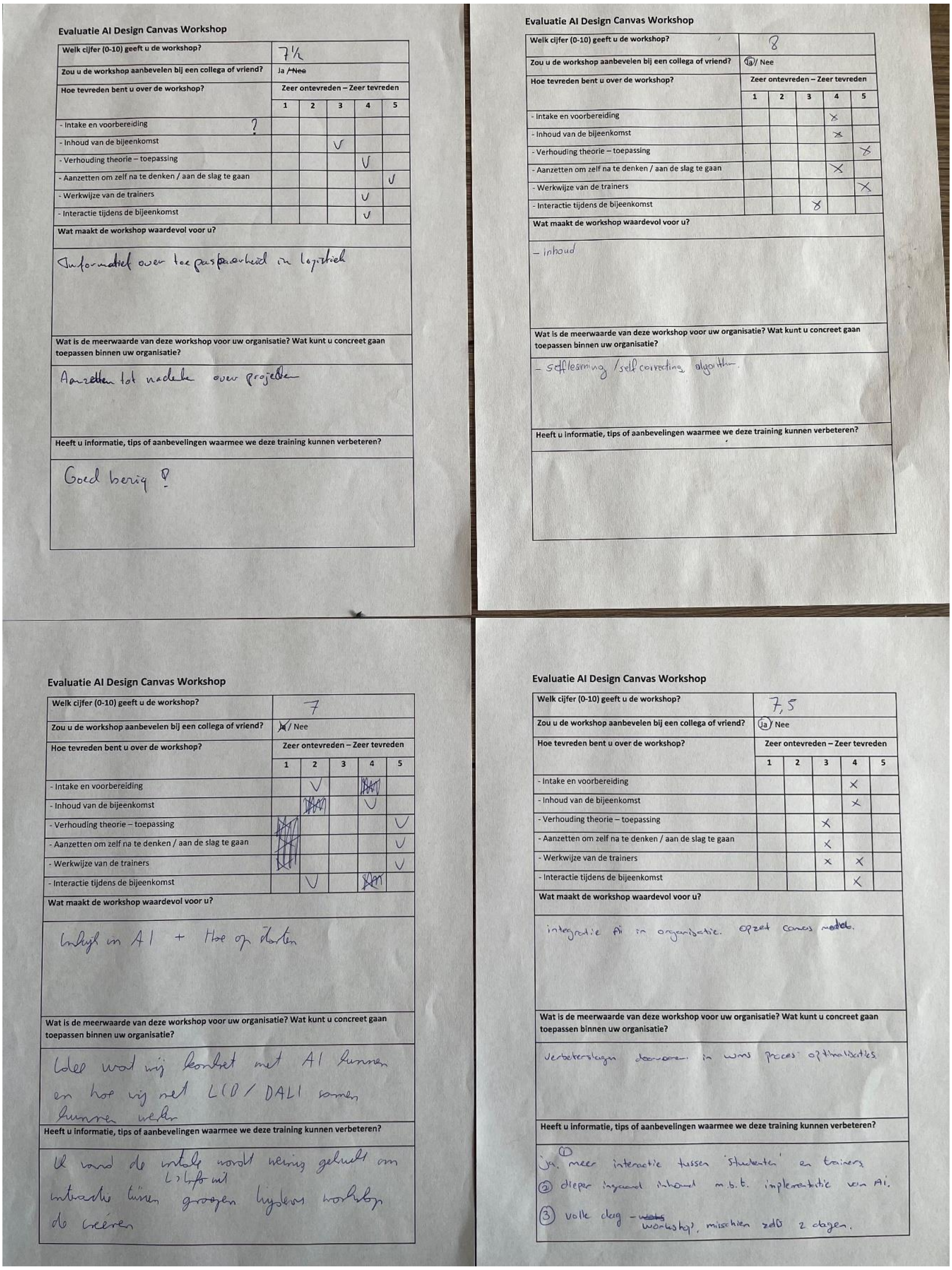
Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Het startpunt is gemaakt / geconcretiseerd.

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

meer tijd nodig

Figure 76: Design canvas workshop evaluation forms participants 1-4.



Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	7½				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja ~~/Nee~~				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding ?					
- Inhoud van de bijeenkomst			✓		
- Verhouding theorie – toepassing				✓	
- Aanzetten om zelf na te denken / aan de slag te gaan					✓
- Werkwijze van de trainers				✓	
- Interactie tijdens de bijeenkomst				✓	

Wat maakt de workshop waardevol voor u?

Informatief over toepasbaarheid in logistiek

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Aanzetten tot nadenken over projecten

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Goed bezig !

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja]/ Nee				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing					X
- Aanzetten om zelf na te denken / aan de slag te gaan				X	
- Werkwijze van de trainers					X
- Interactie tijdens de bijeenkomst			X		

Wat maakt de workshop waardevol voor u?

- inhoud

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

- selflearning / self correcting algorithm.

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	7				
Zou u de workshop aanbevelen bij een collega of vriend?	~~Ja~~/ Nee				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding		✓			
- Inhoud van de bijeenkomst				✓	
- Verhouding theorie – toepassing					✓
- Aanzetten om zelf na te denken / aan de slag te gaan					✓
- Werkwijze van de trainers					✓
- Interactie tijdens de bijeenkomst		✓			

Wat maakt de workshop waardevol voor u?

Inzicht in AI + Hoe op te starten

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Idee wat wij konkret met AI kunnen en hoe wij met LCB / DALI samen kunnen werken

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Ik vond de intake wordt weinig gebruikt om info uit interactie tussen groepen tijdens workshop te creëren

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Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	7,5				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja]/ Nee				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing			X		
- Aanzetten om zelf na te denken / aan de slag te gaan			X		
- Werkwijze van de trainers			X	X	
- Interactie tijdens de bijeenkomst				X	

Wat maakt de workshop waardevol voor u?

integratie AI in organisatie. opzet canvas model.

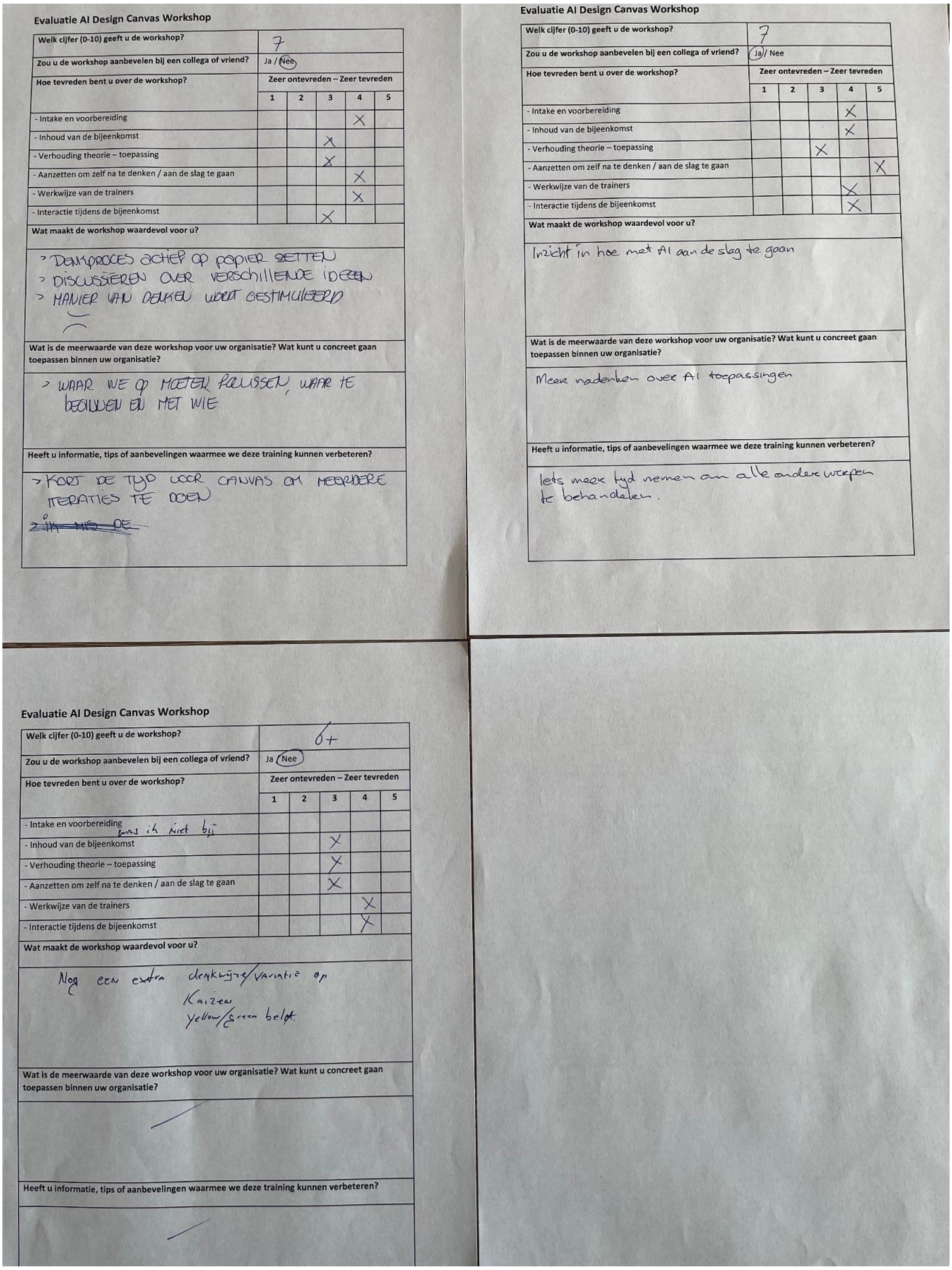
Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Verbeterslagen doorvoeren in wms proces optimalisaties.

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

① ja. meer interactie tussen 'studenten' en trainers.
② dieper ingaand inhoud m.b.t. implementatie van AI.
③ volle dag - workshop, misschien zelfs 2 dagen.

Figure 77: Design canvas workshop evaluation forms participants 5-8.



Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	7				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja / [✓ Nee]				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst			X		
- Verhouding theorie – toepassing			X		
- Aanzetten om zelf na te denken / aan de slag te gaan				X	
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst			X		

Wat maakt de workshop waardevol voor u?

> DENKPROCES actief op papier ZETTEN
> DISCUSSIEREN OVER VERSCHILLENDE IDEEEN
> MANIER VAN DENKEN WORDT GESTIMULEERD

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

> WAAR WE OP MOETEN FOCUSSEN, WAAR TE BEGINNEN EN MET WIE

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

> KORT DE TIJD VOOR CANVAS OM MEERDERE ITERATIES TE DOEN

~~> IK MIS DE~~

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	7				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing			X		
- Aanzetten om zelf na te denken / aan de slag te gaan					X
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst				X	

Wat maakt de workshop waardevol voor u?

Inzicht in hoe met AI aan de slag te gaan

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Meer nadenken over AI toepassingen

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Iets meer tijd nemen om alle onderwerpen te behandelen.

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	6+				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja / [✓ Nee]				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding was ik niet bij					
- Inhoud van de bijeenkomst			X		
- Verhouding theorie – toepassing			X		
- Aanzetten om zelf na te denken / aan de slag te gaan			X		
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst				X	

Wat maakt de workshop waardevol voor u?

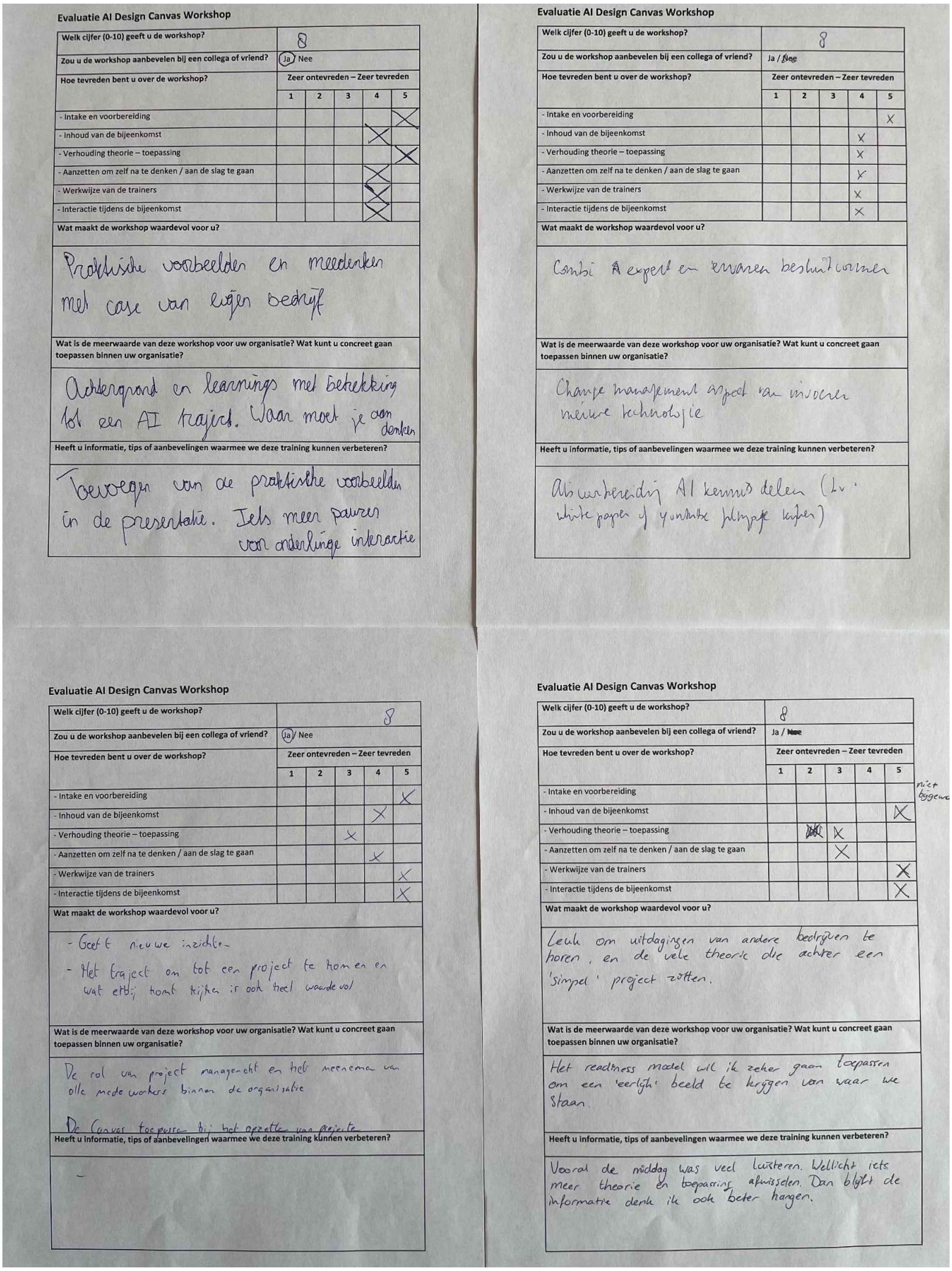
Nog een extra denkwijze/variatie op
Kaizen
yellow/green belt.

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Figure 78: Design canvas workshop evaluation forms participants 9-11.

L.2. 2nd DALI Workshop



Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding					X
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing					X
- Aanzetten om zelf na te denken / aan de slag te gaan				X	
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst				X	

Wat maakt de workshop waardevol voor u?

Praktische voorbeelden en meedenken met case van eigen bedrijf

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Achtergrond en learnings met betrekking tot een AI traject. Waar moet je aan denken

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Toevoegen van de praktische voorbeelden in de presentatie. Iets meer pauzes voor onderlinge interactie

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja / ~~Nee~~				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding					X
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing				X	
- Aanzetten om zelf na te denken / aan de slag te gaan				X	
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst				X	

Wat maakt de workshop waardevol voor u?

Combi ~~A~~ expert en ervaren besluitvormer

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Change management aspect van invoeren nieuwe technologie

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Als voorbereiding AI kennis delen (bv. white paper of youtube filmpje kijken)

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding					X
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing			X		
- Aanzetten om zelf na te denken / aan de slag te gaan				X	
- Werkwijze van de trainers					X
- Interactie tijdens de bijeenkomst					X

Wat maakt de workshop waardevol voor u?

- Geeft nieuwe inzichten
- Het traject om tot een project te komen en wat erbij komt kijken is ook heel waardevol

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

De rol van project management en het meenemen van alle medewerkers binnen de organisatie

De Canvas toepassen bij het opzetten van projecten

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

\-

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja / ~~Nee~~				
Hoe tevreden bent u over de workshop?	Zeer ontevreden – Zeer tevreden				
	1	2	3	4	5
- Intake en voorbereiding					niet bijgewo
- Inhoud van de bijeenkomst					X
- Verhouding theorie – toepassing		~~X~~	X		
- Aanzetten om zelf na te denken / aan de slag te gaan			X		
- Werkwijze van de trainers					X
- Interactie tijdens de bijeenkomst					X

Wat maakt de workshop waardevol voor u?

Leuk om uitdagingen van andere bedrijven te horen, en de vele theorie die achter een 'simpel' project zitten.

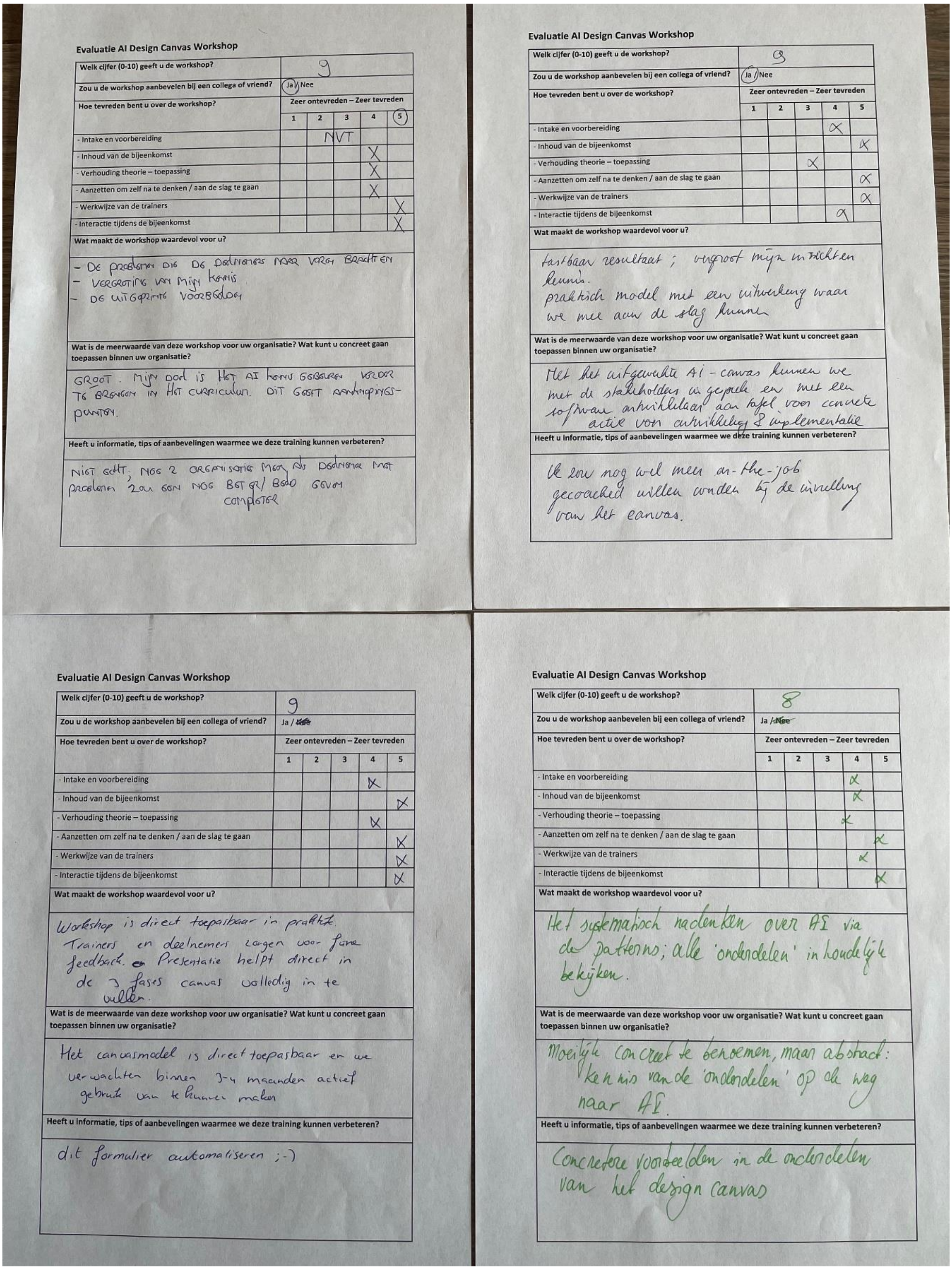
Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Het readiness model wil ik zeker gaan toepassen om een 'eerlijk' beeld te krijgen van waar we staan.

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Vooral de middag was veel luisteren. Wellicht iets meer theorie en toepassing afwisselen. Dan blijft de informatie denk ik ook beter hangen.

Figure 79: Design canvas workshop evaluation forms participants 12-15.



Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	9				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding			NVT		
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing				X	
- Aanzetten om zelf na te denken / aan de slag te gaan				X	
- Werkwijze van de trainers					X
- Interactie tijdens de bijeenkomst					X

Wat maakt de workshop waardevol voor u?

- DE PROBLEMEN DIE DE DEELNEMERS NAAR VOREN BRACHTEN
- VERGROTING VAN MIJN KENNIS
- DE UITGEPRINTE VOORBEELDEN

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

GROOT: MIJN DOEL IS HET AI KANTS GEBEUREN VERDER TE BRENGEN IN HET CURRICULUM. DIT GEEFT AANKNOPINGS-PUNTEN.

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

NIET ECHT; NOG 2 ORGANISATIES MEER ALS DEELNEMER MET PROBLEMEN ZOU EEN NOG BETER/ BEELD GEVEN COMPLETER

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	9				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst					X
- Verhouding theorie – toepassing			X		
- Aanzetten om zelf na te denken / aan de slag te gaan					X
- Werkwijze van de trainers					X
- Interactie tijdens de bijeenkomst				X	

Wat maakt de workshop waardevol voor u?

tastbaar resultaat; vergroot mijn inzichten kennis.
praktisch model met een uitwerking waar we mee aan de slag kunnen

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Met het uitgewerkte AI-canvas kunnen we met de stakeholders in gesprek en met een software ontwikkelaar aan tafel voor concrete actie voor ontwikkeling & implementatie

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Ik zou nog wel meer on-the-job gecoached willen worden bij de invulling van het canvas.

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	9				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja / ~~Nee~~				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst					X
- Verhouding theorie – toepassing				X	
- Aanzetten om zelf na te denken / aan de slag te gaan					X
- Werkwijze van de trainers					X
- Interactie tijdens de bijeenkomst					X

Wat maakt de workshop waardevol voor u?

Workshop is direct toepasbaar in praktijk. Trainers en deelnemers zorgen voor fijne feedback. Presentatie helpt direct in de 3 fases canvas volledig in te vullen.

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Het canvasmodel is direct toepasbaar en we verwachten binnen 3-4 maanden actief gebruik van te kunnen maken

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

dit formulier automatiseren ;-)

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja / ~~Nee~~				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing				X	
- Aanzetten om zelf na te denken / aan de slag te gaan					X
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst					X

Wat maakt de workshop waardevol voor u?

Het systematisch nadenken over AI via de patterns; alle 'onderdelen' inhoudelijk bekijken.

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

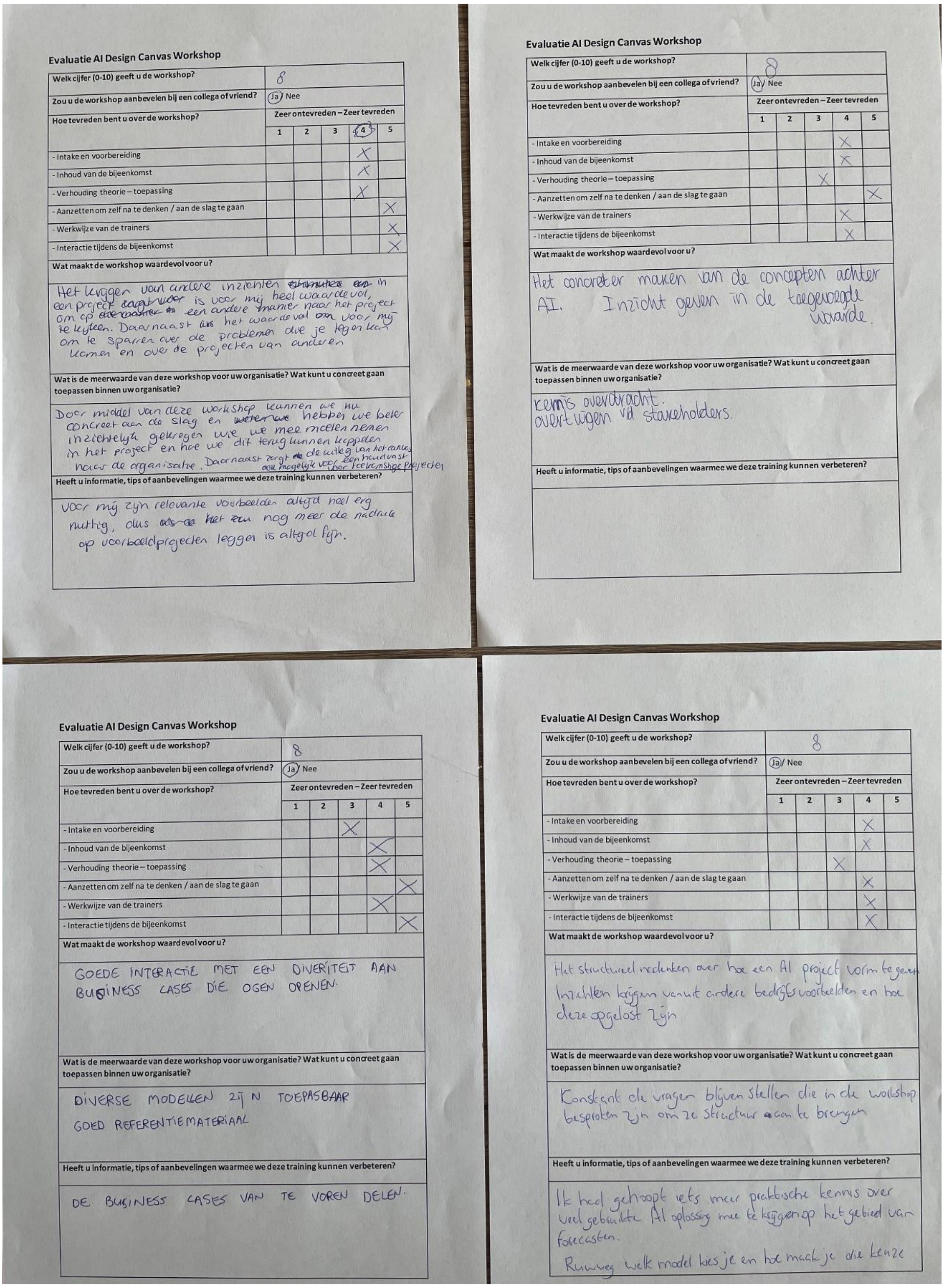
Moeilijk concreet te benoemen, maar abstract: kennis van de 'onderdelen' op de weg naar AI.

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Concretere voorbeelden in de onderdelen van het design canvas

Figure 80: Design canvas workshop evaluation forms participants 16-19.

L.3. 3rd DALI Workshop



Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	[✓ **4**]	**5**
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing				X	
- Aanzetten om zelf na te denken / aan de slag te gaan					X
- Werkwijze van de trainers					X
- Interactie tijdens de bijeenkomst					X

Wat maakt de workshop waardevol voor u?

Het krijgen van andere inzichten ~~[illegible]~~ in een project ~~zagt voor~~ is voor mij heel waardevol, om op ~~[illegible]~~ een andere manier naar het project te kijken. Daarnaast ~~is~~ het waardevol ~~om~~ voor mij om te sparren over de problemen die je tegen kan komen en over de projecten van anderen

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Door middel van deze workshop kunnen we nu concreet aan de slag en ~~weten we~~ hebben we beter inzichtelijk gekregen wie we mee moeten nemen in het project en hoe we dit terug kunnen koppelen naar de organisatie. Daarnaast zorgt ~~de~~ de uitleg van het canvas voor een houvast ~~een mogelijk voor~~ voor toekomstige projecten

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Voor mij zijn relevante voorbeelden altijd heel erg nuttig, dus ~~als de~~ het zou nog meer de nadruk op voorbeeldprojecten leggen is altijd fijn.

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing			X		
- Aanzetten om zelf na te denken / aan de slag te gaan					X
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst				X	

Wat maakt de workshop waardevol voor u?

Het concreter maken van de concepten achter AI. Inzicht geven in de toegevoegde waarde.

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Kennis overdracht.
Overtuigen v/d stakeholders.

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding			X		
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing				X	
- Aanzetten om zelf na te denken / aan de slag te gaan					X
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst					X

Wat maakt de workshop waardevol voor u?

GOEDE INTERACTIE MET EEN DIVERITEIT AAN BUSINESS CASES DIE OGEN OPENEN.

Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

DIVERSE MODELLEN ZIJN TOEPASBAAR
GOED REFERENTIEMATERIAAL

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

DE BUSINESS CASES VAN TE VOREN DELEN.

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	8				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing			X		
- Aanzetten om zelf na te denken / aan de slag te gaan				X	
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst				X	

Wat maakt de workshop waardevol voor u?

Het structureel nadenken over hoe een AI project vorm te geven
Inzichten krijgen vanuit andere bedrijfsvoorbeelden en hoe deze opgelost zijn

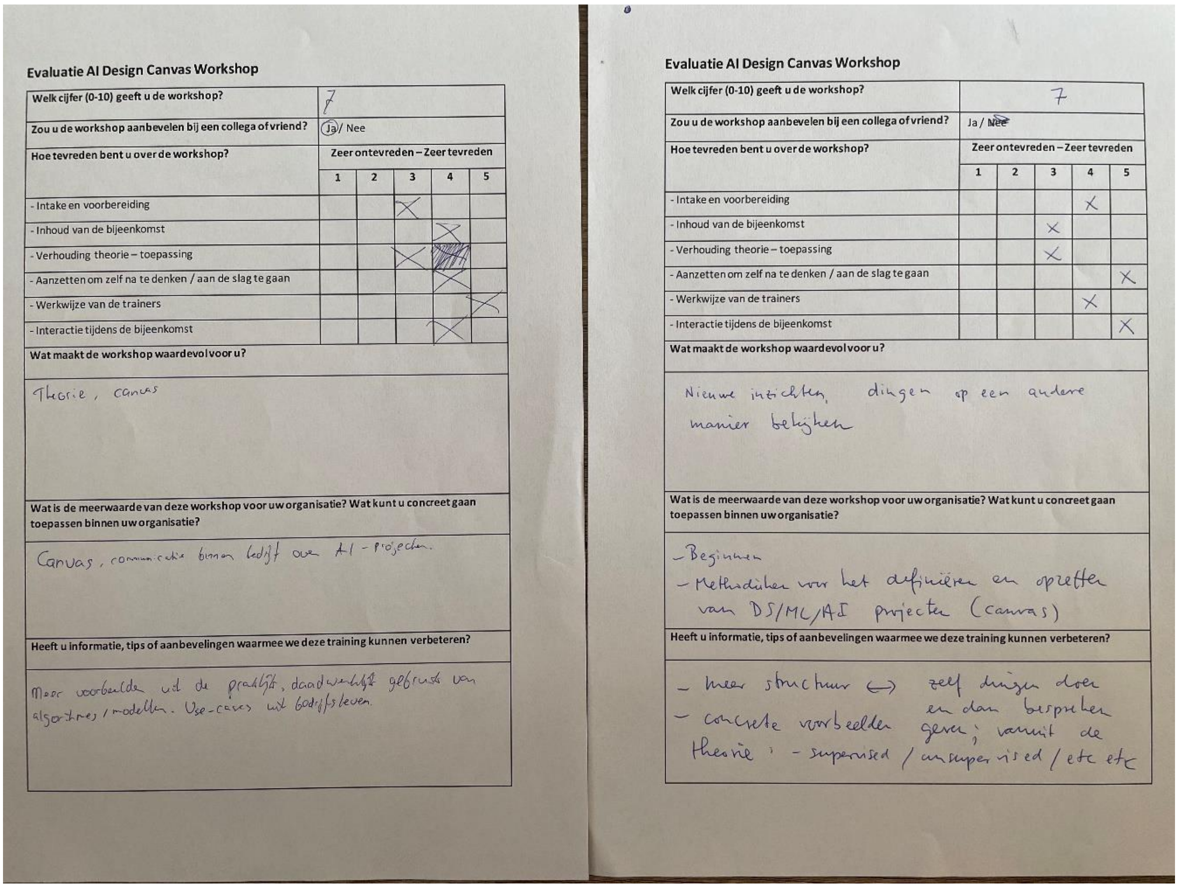
Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?

Constant de vragen blijven stellen die in de workshop besproken zijn om ze structuur ~~[illegible]~~ aan te brengen

Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?

Ik had gehoopt iets meer praktische kennis over veel gebruikte AI oplossing mee te krijgen op het gebied van forecasten.
Ruwweg welk model kies je en hoe maak je die keuze

Figure 81: Design canvas workshop evaluation forms participants 20-23.



Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	7				
Zou u de workshop aanbevelen bij een collega of vriend?	[✓ Ja] / Nee				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding			X		
- Inhoud van de bijeenkomst				X	
- Verhouding theorie – toepassing			X	▨	
- Aanzetten om zelf na te denken / aan de slag te gaan				X	
- Werkwijze van de trainers					X
- Interactie tijdens de bijeenkomst				X	
Wat maakt de workshop waardevol voor u?					
Theorie, canvas					
Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?					
Canvas, communicatie binnen bedrijf over AI-projecten.					
Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?					
Meer voorbeelden uit de praktijk, daadwerkelijk gebruik van algoritmes/modellen. Use-cases uit bedrijfsleven.					

Evaluatie AI Design Canvas Workshop

Welk cijfer (0-10) geeft u de workshop?	7				
Zou u de workshop aanbevelen bij een collega of vriend?	Ja / ~~Nee~~				
Hoe tevreden bent u over de workshop?	**Zeer ontevreden – Zeer tevreden**				
	1	**2**	**3**	**4**	**5**
- Intake en voorbereiding				X	
- Inhoud van de bijeenkomst			X		
- Verhouding theorie – toepassing			X		
- Aanzetten om zelf na te denken / aan de slag te gaan					X
- Werkwijze van de trainers				X	
- Interactie tijdens de bijeenkomst					X
Wat maakt de workshop waardevol voor u?					
Nieuwe inzichten, dingen op een andere manier bekijken					
Wat is de meerwaarde van deze workshop voor uw organisatie? Wat kunt u concreet gaan toepassen binnen uw organisatie?					
- Beginnen - Methodieken voor het definiëren en opzetten van DS/ML/AI projecten (canvas)					
Heeft u informatie, tips of aanbevelingen waarmee we deze training kunnen verbeteren?					
- meer structuur ↔ zelf dingen doen en dan bespreken - concrete voorbeelden geven; vanuit de theorie: - supervised / unsupervised / etc etc					

Figure 82: Design canvas workshop evaluation forms participants 24-25.

Industry surveys of Evofenedex regarding data use and digitalization show that, despite the presence of real-time data and readily available software, organizations in the Dutch logistics industry make limited use of their data. Small and Medium-sized Enterprises (SMEs), which take into account 99% of the organizations, have limited expertise, tools, and resources for digital transformation to realize the benefits of data-driven approaches.

This PDEng thesis contains the results and findings related to the research, design, development, and implementation of an industry platform for data-driven logistics which is tailored to the need of SMEs. This industry platform aims to collectively support SMEs to adopt advanced data-driven approaches by offering a wide range of re-usable algorithms based on the Open Trip Model.

The industry platform is complemented with a design canvas, workshop materials, implementation guidelines, and an adoption framework to transfer data-driven applications to SMEs as part of a learning community.

Building bridges between science and supply chains

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He holds a double Master degree in Supply Chain Management and Business Administration (2017) and Bachelor degrees in Industrial Engineering and Management (2011) and Human Resource Management (2007).

Previously, he worked 10 years in the information technology and services industry and consulted organizations in the logistics industry.

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