Master of Science in Software Engineering
Ferbruary 2022

Machine Learning in Regulatory Compliance Software Systems: An Industrial Case Study

Maryam Rezaei

Faculty of Computing, Blekinge Institute of Technology, 371 79 Karlskrona, Sweden

This thesis is submitted to the Faculty of Computing at Blekinge Institute of Technology in partial fulfilment of the requirements for the degree of Master of Science in Software Engineering. The thesis is equivalent to 20 weeks of full time studies.

The authors declare that they are the sole authors of this thesis and that they have not used any sources other than those listed in the bibliography and identified as references. They further declare that they have not submitted this thesis at any other institution to obtain a degree.

Contact Information:
Author(s):
Maryam Rezaei
E-mail: marz19@student.bth.se

University advisor:
Assistant Professor Lawrence Henesey
Department of Computer Science

Faculty of Computing
Blekinge Institute of Technology
SE–371 79 Karlskrona, Sweden

Internet : www.bth.se
Phone : +46 455 38 50 00
Fax : +46 455 38 50 57

Abstract

The presented study investigates the role of Artificial Intelligence(AI)/Machine Learning(ML) in Regulatory Compliance software systems by conducting a case study in the maritime industry. There is a need to obtain a clear understanding of Machine Learning approaches for automating regulatory compliance.

Background. Organizations and software developers face different regulations in different domains that need to be satisfied by the requirements of systems. Trading across borders brings challenges in managing each country's regulatory requirements. Even though a large amount of efforts from international and local organizations, an efficient AI-based system is not yet fully deployed for offering decision support in handling such complex issues as a viable solution. [13] The increasing enforcement of sanctions and anti-money laundering by various institutions and countries poses a significant threat to many industries worldwide if they are not educated or aware of the legal and financial risks. Therefore, Regulatory Compliance plays a critical role in this area. Regulatory Compliance is a guideline for laws or regulations related to the business that the stakeholders must abide by to promote a safer business environment and benefits to society. Developing a Digital Compliance(DigiComp) system as software service is a solution that involves both technical and organizational challenges which need a large amount of research. As a case study an AI-based DigiComp system has been implemented in the port of Vordingborg for the EU-financed project "Connect2SmallPorts ". A major corporate challenge was the choice of appropriate and efficient approaches and tools for designing the automated regulatory compliance system. [24] This study investigates the role of AI/ML in regulatory compliance system and its possible opportunities and limitations.

Objectives.

The significant role of compliance management made it an interesting research topic since some highly regulated systems need to follow specific laws and guidelines. As the objectives of this study, the role of Machine learning on regulatory compliance systems has been investigated by extracting the most popular ML approaches and their benefits and challenges from previous studies and then analyzing the related benefits and limitations in a real-world case.

Methods. We have conducted a systematic literature review as the qualitative research method with database search and snowballing to collect the applied Machine Learning approaches and their benefits and challenges for Regulatory compliance software systems. Then a Case study was conducted for implementing a regulatory compliance system in maritime industry and investigate the benefits and challenges in a real world project. Also Focus Group and Interview with the stakeholder and domain experts were held as data collection methods during the Case Study process.

Results. After investigating the existed challenges in the regulatory compliance process and identifying the risk assessment framework based on Machine Learning as the most popular AI approach in this area, we have implemented a risk assessment framework based on Neural Network. It provides high accuracy and low error rate in predicting the future state to prevent the non-compliance risk.

Conclusions. Examining the proposed digital compliance system explores its similarity to the benefits and limitations extracted from SLR. Developed a new AI-Based system which can inspire software companies to build more efficient regulatory compliance systems for different domains in the industry.

Keywords: Digital Compliance, Regulatory Compliance, AI-Based system, Machine Learning, Risk Framework.

Acknowledgments

I would like to thank my supervisor, Dr.Lawrence Henesey, for his invaluable support, patience, and guidance throughout my thesis. Without his help and motivation, I would not have completed my thesis. He had many insightful conversations during the development of this thesis idea and valuable suggestions on the topic.
Besides, I am thankful to Alexandr Silonosov, the project assistant in the case study project for his contribution.
My special thanks to all the experts and practitioners who have taken the time to help me out and all who, directly or indirectly, have lent their unfailing support throughout this study.
Appreciation is also given to the EU projects: Connect2SmallPorts and SECMAR, in which I was able to conduct part of my research as a project assistant. This helped immensely in understanding Compliance and the issues that plague it.

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Chapter 1

Introduction

The presented study introduces the advantages and limitations of Artificial Intelligence(AI) and Machine learning(ML) for regulatory compliance automation. A Digital Compliance system has been presented as the case study to show how the challenge of increasing complexity in regulatory compliance can be addressed by using machine learning algorithms and its possible limitations.

1.1 Background

Various studies exist on the investigation of computer programs and associated software-implemented techniques for designing automated frameworks to manage compliance with relevant policies.
New regulations are being ordained in international trading industries to detect fraud and prevent money laundering. It increases the risk of non-compliance for organizations and companies in different domains. So Regulatory Compliance plays a critical role in this area and developing an AI-based system for digitalizing compliance is needed to overcome the challenge.

The increasing nature of globalization, which is now further fueled due to digitization, has realized immense possibilities for society in ordering items and then being transported across the globe for delivery. Though the growth in global trade is regarded as a positive effect for society, it increases the growing complexity in terms of the products and services. Complex networked and cloud-based systems made the organizations and software developers comply with many regulations from different domains simultaneously. In the past, the only way companies, organizations, and even countries knew that they were at fault for non-compliance was when they were fined. For example, the financial industry for 2019 was charged nearly 10 billion dollars in fines[1]. Therefore, there is a need for an efficient regulatory compliance software system in the industry. Regulatory compliance would be tricky when organizations want to comply with all relevant law elements, and the new regulations cause more challenges. We choose Digital Compliance for Maritime as the case study to look closer at the challenges we may face in requirement specifications an other steps of software development.

[1]https://www.fenergo.com/press-releases/aml-kyc-sanctions-fines-for-global-financial-institutions-top-36-billion-since-financial-crisis/

1.1.1 Digital Compliance

Companies in international chains must share information to prove compliance with various requirements. Since for many business processing, particularly shipping companies(the conducted case study in this research is related to the maritime industry) , most data exchanges are still paper-based; hence it is considered burdensome and time-consuming. Moreover, the digitalization of the shreds of evidence is expected to make providing and sharing Compliance information more manageable and efficient. Such developments, however, require concerted actions by a wide range of stakeholders involved in the data-sharing processes. Regulatory Compliance is a guideline for laws or regulations related to the business that the stakeholders must abide by to promote a safer business environment and benefits to society. Digital Compliance refers to digitalizing the process of complying with regulations in different domains and industries.

1.1.2 Know Your Customer (KYC)

Know Your Customer proceess is a robust solution for identity management and anti-money laundering to be in compliance with regulations[29] An automated regulatory Compliance system is an example of KYC that is necessary in this fast-paced world because the business environment becomes complicated, and it is impossible to handle the processes manually.

Any problem from third-party vendors or suppliers or their fraudulent and illegal behavior cause business disruption such as losing clients or business relationships and impacts reputation towards clients and investors[39].
The KYC process is fulfilling all required obligations in customer identification. There are many specific rules needed to automate identity infrastructure and investigate how applying efficient technologies such as AI/ML approaches creates opportunities for solving the challenges of possible customer's risks[5].

1.1.3 Artificial Intelligence and Machine Learning

Artificial Intelligence and its constituent technology, Machine Learning, allow machines to behave, act, sense, and learn like humans. Its prominent benefit is the low human resource costs while maintaining a high level of relationship and activity.Machine learning approaches include three types of Learning: Supervised Learning(SL), Semi-supervised Learning(SSL) and Unsupervised Learning(UL). UL needs more complex data processing to determine the right answer, and It can create outputs by clustering data based on their training to identify patterns in a dataset. Machine Learning is transformation process, and it depends on the relationship between people and machines based on the rate of phenomena. Artificial Intelligence works based on human ingenuity but sometimes outperforms humans that is alarming[46]. development of computer systems for performing tasks that were traditionally done by human intelligence creates Artificial Intelligence[28].

1.2 Scope and Problem statement

Although some studies investigated security requirement engineering, they do not offer proper solutions for requirement specifications in regulatory compliance systems to address the challenges of organizations or companies facing the regulations[4]. Regulatory compliance needs to establish the jurisdiction as to place which law should be considered and then determine how to comply by modeling the laws and the requirements for such software systems[26]. Therefore regulatory compliance plays a critical role in this area, and digital compliance through an AI-based system is much needed to comply with existing regulations.
In the other hand, Digitazilation has enabled the development of ever-increasing sophistication in data analysis. For example, contracts between the suppliers and the customers were mostly made with no exchange of documents, and written pledges or trading across borders bring challenges in managing each country's regulatory requirements. Many experts have expressed the need for information systems designed, developed, and then deployed for offering decision support in handling such complex issues as a viable solution. Still, they are not fully deployed because of the gap in requirement specification for this system to comply with existing regulations.
Problem Formulation: The major corporate challenge is the choice of appropriate strategies for designing and implementing a software system to develop an efficient regulatory compliance system.
In this research the literature in related areas (discussed in Chapter 2) provides describing the challenges in regulatory compliance in the software development process for automating regulatory compliance. The conducted systematic literature review shows that how Machine Learning could improve the regulatory compliance issues and what are the most popular Machine Learning approaches in this area. Another step is conducting a case study in the maritime industry to critically explore the opportunities, challenges and implications of Machine Learning in a real-life Digital Compliance scenario by mapping the benefits and challenges of proposed system to the advantages and limitations of Machine Learning approaches were extracted from systematic literature review.

1.3 Aim and Objectives

The study aims to understand the Artificial Intelligence and Machine Learning role in automating regulatory compliance, including its related opportunities and limitations, to identify the most popular machine learning approaches in this area.

Objectives

- Look for the benefits and challenges of Machine Learning approaches and their implications in this kind of automation by conducting a systematic literature review:.
  -To explore the popular AI/ML approaches in developing regulatory compliance systems that were presented in previous studies.
  -To identify the benefits and challenges of extracted AI/ML approaches from studies.

- To explore the possible opportunities and limitations in a real world case by conducting a case study. An AI-based regulatory compliance system was implemented in the maritime industry to investigate the benefits and challenges of applying AI/ML approaches and compare them with the findings from SLR.

1.4 Outline

The thesis structure is as follows. Chapter 1 consists of introduction overview, problem definition, the aim and objectives, the research scope, and the research contributions. Chapter 2 provides the background and related work of the topics in this study. The research gap in this topic is also mentioned. Chapter 3 presents research questions and the research methods used to implement this thesis. Chapter 4 provides the results and analysis of the results from conducted research methods, systematic literature review, case study and focus group. Chapter 5 presents the answers of the research questions through the applied research methods and the threats to validity for each of them. Chapter 6 provides the conclusions made in this thesis, and suggestions are discussed for any future work.

Chapter 2

Research Gap and Related Work

2.1 Related work

Globalization and Information Communication Technology cause increased business opportunities and raise challenges in regulatory compliance[16].
Regulatory requirements that must be complied with by businesses and organizations increase every day and raise the need for adapting to the complex regulatory environment[19].
The study by [12] defined compliance as meeting the legal requirements, industry standards and accepted ethical norms. Regulatory compliance is a set of policies to ensure the business goal complies with the relevant requirements[27].
There are three compliance rules that are modeled for business processes. First is Regulations, the second one is information technology and tha last one is quality standards.[15].
A practical suggestion for diverse regulatory compliance in business is to integerate three key points. First is Governance, Second is Risk and the other one is Compliance (GRC).[11].
Complying with regulations is trending in different contexts, such as cloud computing and business process management[8].
Determining if an IT(Information Technology) system could meet the compliance requirements is a general idea for regulatory compliance management[22].
An analyzable format of compliance requirement and a formal process model is needed to enable automated compliance checking. It defines how a similar structural pattern to the process model comply with regulations[18]. One trillion dollars was spent on regulatory compliance worldwide[20]. Therefore, regulatory compliance has become a trending topic in the ever-increasing society and industry. IT (Information Technology) solutions and Artificial Intelligence have been applied to tackle the challenge of non-compliance issues. The conducted study[20] indicates the classification of texts in an AI model to identify the critical clauses in regulations.
Regulatory compliance system is a need to tackle the challenge of Increasing rate in new regulations and requirements and the rise in non-compliance fines and also business disruption[37].

There are different kinds of challenges in the regulatory compliance software development process such as requirements specification. The serious limitations on accessing the business regulations and the difference between compliance context for different products rise challenges in this area[49].

2.1.1 Research gap

Regarding the findings from background and Related Work section, The existed challenges in regulatory compliance systems were investigated. However an efficient Regulatory Compliance system that would be practical in different industrial and academic domains was not fully deployed. this study demonstrate the role of AI/ML in improving these kind of systems to identify the possible benefits and challenges from previous studies and a real world case study.

2.2 Research Contribution

The main contributions of this research are investigating the opportunities, challenges, and limitations of AI/ ML in regulatory compliance systems that extracted from SLR and also experienced in designing a Digital Compliance system in the maritime industry as the conducted case study. This work has produced a piece of knowledge worth knowing by conducting a systematic literature review. It indicates what is already known about our particular topic and what different ML approaches have been applied before. Our contribution is viewed as a starting point for further research into implementing an efficient AI-based regulatory compliance system using various tools and technologies. The findings of this research are as follows:

- A list of Machine Learning approaches applied in regulatory compliance systems and the benefits and opportunities they could provide.
- A list of the challenges and limitations of Machine Learning approaches for regulatory compliance system.
- To investigate the possible improvement by applying the ML algorithms in a real world case to tackle the challenge of non-compliance.

Chapter 3

Research Methodology

3.1 Research Questions

The thesis aims to describe how Machine Learning approaches can improve regulatory compliance system and investigate associated challenges and opportunities. To achieve this aim, we defined the following research questions:

- RQ-1: What are the most popular Machine Learning approaches applied for regulatory compliance systems and their benefits?
  Motivation: Explore the most popular ML algorithms to understand and gain in-depth knowledge about The role of AI/ML on automating regulatory compliance, including its purpose, scope and benefits.

- RQ-2: What are the challenges related to applying Machine learning approaches in regulatory compliance system, their reasons, and implications?
  Motivation: Investigate the challenges and limitations of using AI/ML approaches faced in different case studies from the reviewed literature.

- RQ-3: What are the possible improvements and limitations related to automating regulatory compliance system using Risk Framework as a popular Machine learning approach in this area?
  Motivation: To seek answers for this question, we conducted case study research to implement a risk management framework and compare its benefits and challenges with the findings from SLR. Focus Group method and Interview method were applied for Data Collection during conducting the Case Study.

  We extracted the ML approaches and their benefits and opportunities from the literature and implemented an AI-based regulatory compliance system to explore to what extend we can see the possible improvement and challenges in a real case comparing with the findings from SLR.

3.2 Research Methods

This thesis will answer the listed research questions mentioned earlier by applying different research methods: Systematic Literature Review , Case Study, and Focus Group and interview as data collection tools. We employed different approaches to providing comprehensive and reliable results. After conducting a systematic literature review as the qualitative method, we have conducted a case study to see the

benefits and challenges of AI/ML approaches for regulatory compliance systems in a real world project. Qualitative, quantitative, and mixed methods are the three types of research methods.[36] Quantitative methods use numbers and close-ended questions, while qualitative methods use words and open-ended questions, and they have a flexible nature. The obtained data in these methods will be in text or format and analyzed based on themes and patterns[21] table 3.1 indicates the employed methods during this research and the related data sources.

Research Questions	Methods	Qualitative / Quantitative	Data Sources
RQ1 , RQ2	Systematic Literature Review	Qualitative	Literature
RQ3	Case Study	Mixed	Stakeholders, area experts and results of ML algorithm
RQ3	Focus Group	Qualitative	Stakeholders and area experts
RQ3	Interview	Qualitative	Stakeholders

Table 3.1: Methods and Data collection

- RQ1: To answer this research question, we identified the Artificial Intelligence and Machine Learning approaches have been applied in regulatory compliance systems. The first step is a systematic literature review to gather the existing literature, increase knowledge, and extract the ML approaches on automating regulatory compliance, including their purpose and benefits.

- RQ2: To answer RQ2, we identified the challenges and limitations of AI/ML approaches through conducted the systematic literature review.

- RQ3: We investigate the possible benefits and challenges in developing regulatory compliance when using ML approaches by conducting a case study in a real-life case to design and implement an AI-based Digital Compliance system based on software engineering practices in an E.U. financed project, "Connect2SmallPorts". The case study provides a deeper understanding of extensive phenomena and a real-world issue in a small scope. It is conducted for exploratory purposes.

  We had gone through the software development process based on the leading software engineering steps in this project. We conducted focus group discussions and interview with the stockholders and the domain experts in the requirement specification step. Findings from the related work relevant to regulatory compliance system and the results from the conducted SLR were presented to the participants in the beginning.

3.2.1 Systematic Literature Review

The main planning for the systematic literature review is shown step by step in Figure 3.1. In this thesis, we will follow three steps for SLR. First, develop and evaluate the review protocol according to the identified needs. Second, search

and select research papers according to assessment criteria. Third, we report and document the study results [30]. With a literature review, we can find relevant research papers that focus on a similar research problem.

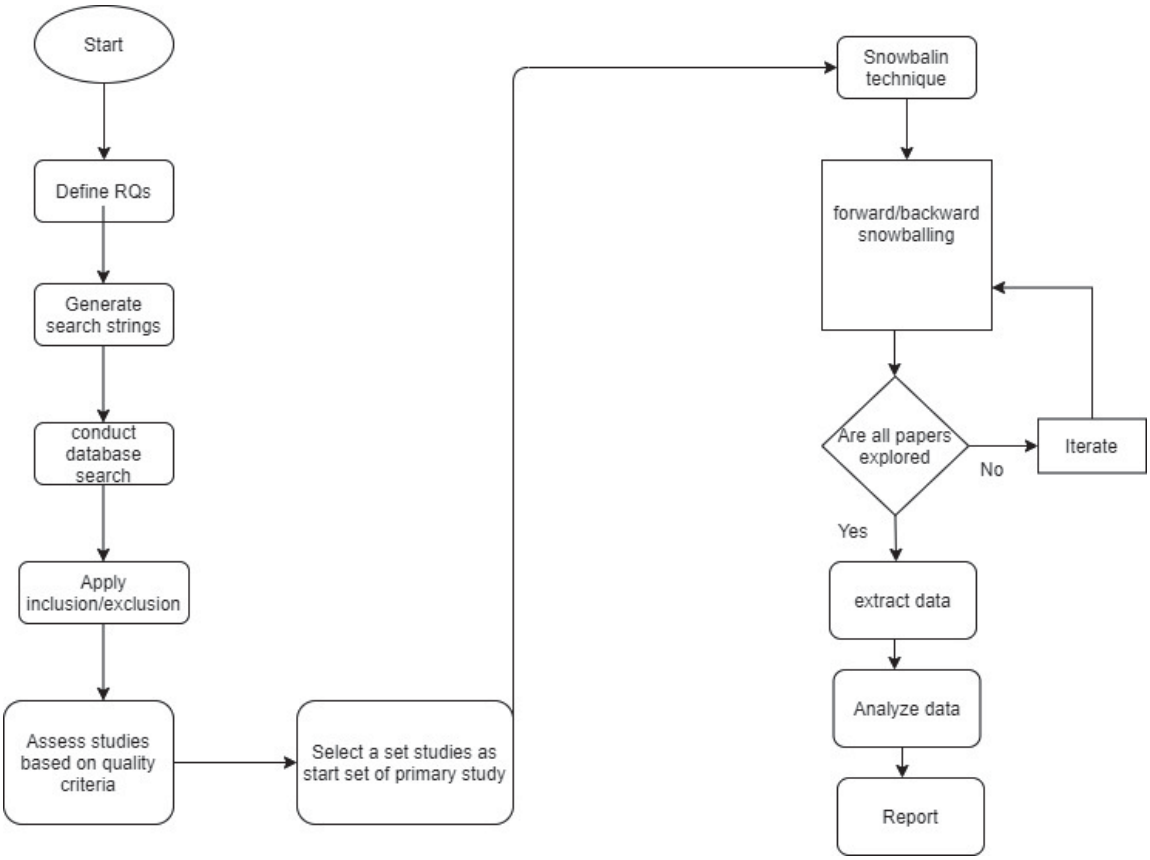


Figure 3.1: Systematic Literature Review steps

The search strategy in our research protocol includes the list of academic libraries that will be searched (Scopus, ACM Digital Library, IEEE Xplore, Springer Link) We have conducted a database search based on the following search strings.

- SS-1: (“Compliance” AND “Regulations”) AND “Machine Learning”.
- SS-2: (“Compliance” AND “Regulations”) AND “Artificial Intelligence”.
- SS-3: (“Regulatory Compliance” And "Automation") And “Artificial Inteligence”.
- SS-4: (“Regulatory Compliance” And "Automation") And “Machine Learning”.

Then apply Inclusion/Exclusion criteria to remove the irrelevant and duplicate studies.

Inclusion Criteria

- Available in English language.
- Available in full text.
- Studies that focus on applying AI/ML for automating regulatory compliance.

- Conference articles and journal articles.
- Studies published after 2005.

Exclusion Criteria

- Grey literature.
- Not available in English.
- Not available in full text.
- Duplicate studies.

To decide on a particular paper we will assess it based on defined quality criteria.

Quality Criteria

- The study provides a knowledge related to AI/ML approaches for automating regulatory compliance or the related benefits or challenges.
- The results and conclusion are clearly stated.
- The aim and objectives of the research are clear.

The final selected papers will be the start set for snowballing technique. Forward snowballing refers to identifying new articles based on those papers citing the paper being examined and backward snowballing means using the reference list to identify new papers to include[51].

Snowballing

There is a challenge of identifying good papers in database search and the possibility of losing some relevant and proper studies. Iterations in snowballing help to identify seminal and highly cited papers in the considered area[51] Once the final analysis in the database search specifies the start set and decides about their inclusion, forward and backward snowballing will be started.
Backward snowballing uses the reference list to identify new studies to include. At the first step, the papers which do not fulfill the basic criteria as publication year, language, and duplicate studies are excluded. In the next step, the titles are examined to ensure they are relevant to our study area. For the remaining studies, the abstract is read, and then other parts of the paper decide to include or exclude the paper.
Forward snowballing starts with a particular article from the beginning set to find citations to the paper. The title should be searched in Google Scholar to see the number of papers citing the article. Each candidate citing the paper is examined based on the inclusion/exclusion criteria, then the abstract is read, and if it is insufficient, the full text is studied to decide on the new paper. The same inclusion approach is applied to identify new relevant papers[51]

3.2.2 Case Study

A Case Study was conducted following the guidelines by Runeson and Höst[43] to answer the third research question. The case study research methodology has been conducted to implement a risk framework for the proposed DigiComp system by applying machine learning algorithms. The motivation of choosing a case study is to investigate the role of Artificial intelligence and Machine learning in regulatory compliance software systems. The risk management platform is an automated framework to analyze and manage the compliance with relevant regulations and policies in different domains[45]. As a part of the Digital Compliance (DigiComp) project team in the south Baltic financed by the E.U. in the Connect2smallports project, we have implemented a working AI-based Digital Compliance system that is tested in the maritime industry. We have used the API from "marinetraffic.com [1]" which provides large amounts of AIS (automated identification systems) data in real-time and included the sanctions list from "OFAC," the Office of Financial Accounting Contol, and the list of extracted required Compliance for each entity in the marine industry.

Case and context

The case study was conducted to design and implement a Digital Compliance system at Vordingborg port in Denmark; that is an example of a case that needs to comply with regulations to provide a safe business. Petersen and Wohlin in ref. provide a checklist to describe the context of a case for industrial software engineering research including: product, process, practices/tools, people, organization, market. The following figure indicates the Context Facets of our case study.

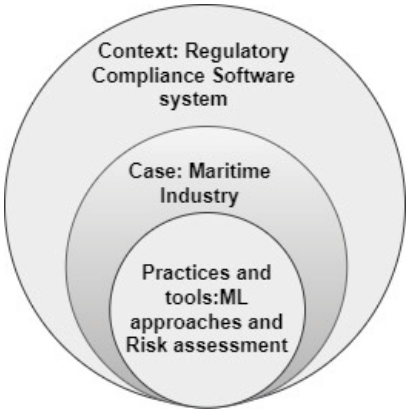


Figure 3.2: Context Facets of conducted Case Study

Market and Product

According to statistics available online at MarineTraffic.com, port of Vordingborg provide services in different domains. The type of vessels arrived in 10 days (since May 2021) presented in following Figure.

[1] marinetraffic.com

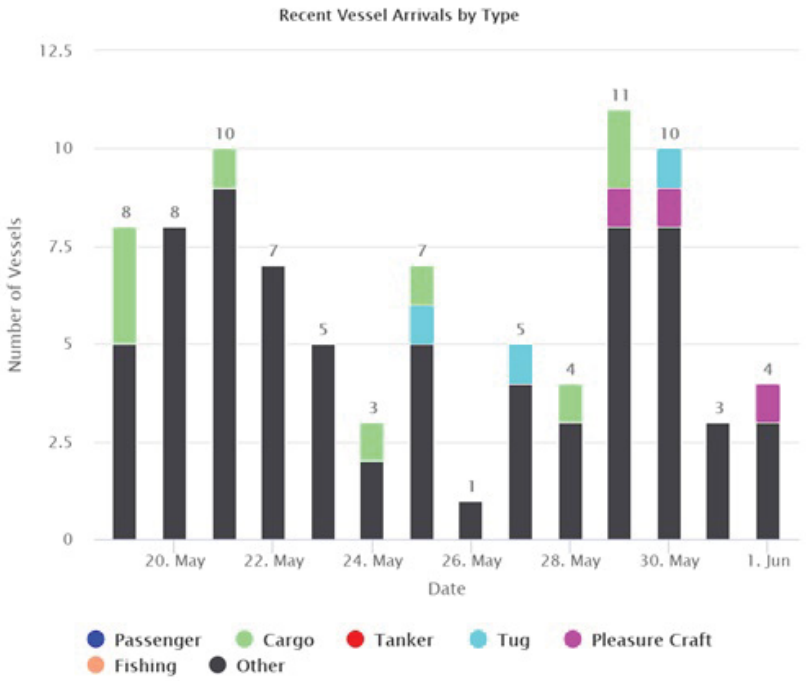


Figure 3.3: Traffic statistics for Vordingborg (Source; marinetraffic.com)

Organization and Process

The following table indicates port of Vordingborg provides services for international vessels and charterers transporting cargo from countries outside EU including Russia and United Kingdom according to "Origin Port Country". we have collected these data from MarineTraffic.com.

Vessel Name	Date of Arrival	Origin Port Country	Vessel Capacity - Dwt
BUGSIER 15	2021-05-30 08:44	DE	102
EEMS CARRIER	2021-05-29 07:13	DE	2200
GERMANICA HAV	2021-05-28 05:28	SE	2296
MORAG M	2021-05-25 21:08	NL	130
VINES	2021-05-25 14:12	SE	2376
KERTU	**2021-05-24 07:32**	**RU**	**4800**
FEED FISKAA	2021-05-21 08:08	DE	4178
RIX ATLANTIC	2021-05-19 22:43	DE	3793
BRIGITTE F	2021-05-19 08:01	DE	3732
FRI TIDE	2021-05-18 18:21	IE	3649
AMADEUS	**2021-05-18 05:54**	**GB**	**1680**
LAFJELL	2021-05-08 22:11	SE	4228
LISTERLAND	2021-05-08 10:23	SE	4025
INGEBORG PILOT	2021-05-06 04:41	SE	3004
AMADEUS	2021-05-05 14:25	SE	1680
SANDETTIE	2021-05-04 23:37	NL	2934
BALTIC MOON	2021-05-04 03:33	DE	3850

Figure 3.4: Traffic statistics for Vordingborg Port by countries since May 2021 (Source; marinetraffic.com)

3.2.3 Focus Group

The focus group was conducted to discuss and elicit participants' views on the topic related to RQ-3. It was held in a semi structured setting[35]. The results from related works and conducted SLR helped us identify, collect and prioritize data that was important to the participants. It gave participants a more sense of involvement in the research process and flexibility to use results from RQ-1 and RQ-2 in the considered case study[33].

The objective of focus groups is to elicit the requirements for designing the AI-based system to tackle the challenge of non-compliance. The participants for the focus groups are domain experts and Stakeholders. The demographics of participants are given in the following table.

ID	Name	profession	Work experience
1	Jan Jaap Cramer	CEO in Vordingborg Port	9 Years
2	Pradeep Pant	Commercial Director (Compliance and Fintech)	17 Years

Table 3.2: Demographic of participants in Focus Group and Interview

In advance, the agenda for focus groups and a summary from earlier findings were shared with the invited participants. The plan and topics covered in each focus group meetings are as follows. Focus group aimed at eliciting the requirements for the AI-based regulatory Compliance system. The plan included:

- Introducing the benefits of automating the regulatory compliance process to address the challenge of manual works in this area and the risk of non-compliance.

- Presentation and a brief discussion on the findings from RQ-1 and RQ-2 related to the opportunities.

- Presentation of findings from the related work relevant to regulatory compliance system and analysis of their challenges.

- Discussion on identifying the requirements for the Digital Compliance system. The whole focus group discussions' duration through online meetings was more than 6 hours. The gathered data from the group discussions were collected as handwritten notes and after compiling them sent to participants for verification and feedback information.

3.2.4 Interview

The third step in the thesis is an interview study. The motivation for selecting this approach was to perform research to get feedback from practitioners about the proposed integrated model of blockchain and DevOps to add knowledge about these technologies for regulatory AI-based systems in real-world phenomena. conducting Interview as an empirical method for data collection provides insights into qualitative research goals to extract meaningful and valuable information from experts' knowledge and experience on the integrated model. There are some restrictions for participating in surveys in some companies, thus we have chosen interview over survey to gain explicit information from the practitioners. We conducted semi-structured interviews, audiotaped and transcribed them. Structured interviews are closed-ended and analyzed statistically. The questions are very specific and they are asked exactly without deviation.[44] We have applied semi-structured interviews because of their open-ended characteristics. It facilitates more interaction, and we obtain higher quality and unexpected responses, and new information is gathered from further questions.[47] Relevant measures of software developments are often collected using semi-structured interviews since they are qualitative phenomena.[25] estimating the necessary effort is important for planning to allocate enough resources and time. Interviews include different activities that should be considered before starting the process. Scheduling the interviews and sending the interviewees, collecting interviewees' background information to ensure that they have the required skills, preparing interview guide that we discuss later, writing and transcribing the audio taped interview. Choosing appropriate tools and artifacts such as tape recorder and visual artifact for providing more formative information are essential to enhance the quality and efficiency of the interviews.[25] Figure 3.3 presents the steps followed in this interview study.

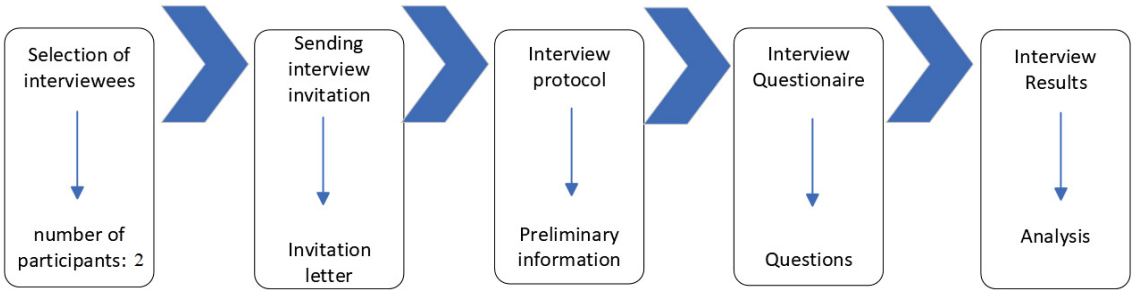


Figure 3.5: Interview Steps

In this study since the intent is not to generalize to a population but to develop an in-depth exploration of a central phenomenon, it is best achieved by using purposeful sampling strategies for selecting the interview respondents. two respondents were interviewed using Zoom. The interviewees are domain experts experienced with regulatory compliance. We were given permission for audio recording and each interview lasted for between 30-45 minutes. The interview study provides a systematic assessment of the AI-based system with real world effects and helps in specifying the requirements. Analyzing the benefits and challenges of the proposed system gives high-quality information from the experts shared their experience within this field. The experts' data is further analyzed based on how the proposed model affects the organization's Regulatory Compliance issues. Qualitative methods are used to analyze the semi-structured interview data.

The practical understanding of the DigiComp system benefits can be evaluated since after analysing data by coding and themes we synthesize the data and map the benefits and challenges to findings gathered from literature review. for analyzing the data from interviews we applied qualitative thematic analysis with several steps as transcribing, organazing the data and then coding and identifying the themes and interpreting them.

There is a question here about why the interview has been chosen as the research method in this part. The objective of this study is to implement a DigiComp system, based on software engineering practices. We needed to gain more information regarding its requirement specifications and execution and the potential opportunities or impacts on the company strategy. The best solution was using some experts knowledge in this area. The benefits of regulatory compliance system and the proposed idea of implementing an AI-based system was presented as preliminary information to the interviewees.

3.3 Alternative Methods

- **Survey:** As the outcome of our research is a potential design of a software system, conducting a survey is not a suitable method here since structured information from a population is not needed. We need to evaluate our proposed model by collecting data from a few experts and stakeholders who have enough knowledge in this area because we have implemented AI-based regulatory compliance system in the maritime industry.

- **Experiment:** An experiment is applied to variables of a controlled environment to measure the changes and see the degree of influences; however, we do not need manipulating variables in this study.

- **Action research:** Action research methodology is applied in social science for the simulation of doing research by critical reflection. Its goal is to solve an organizational problem based on the collaboration between the researcher and someone from that organization. This study is conducted to propose the integration of two technology and investigate how Blockchain can solve the DevOps challenges. Therefore, according to the characteristic of action research, it is not an appropriate research methodology here.

Chapter 4

Results and Analysis

4.1 Results from Literature Review

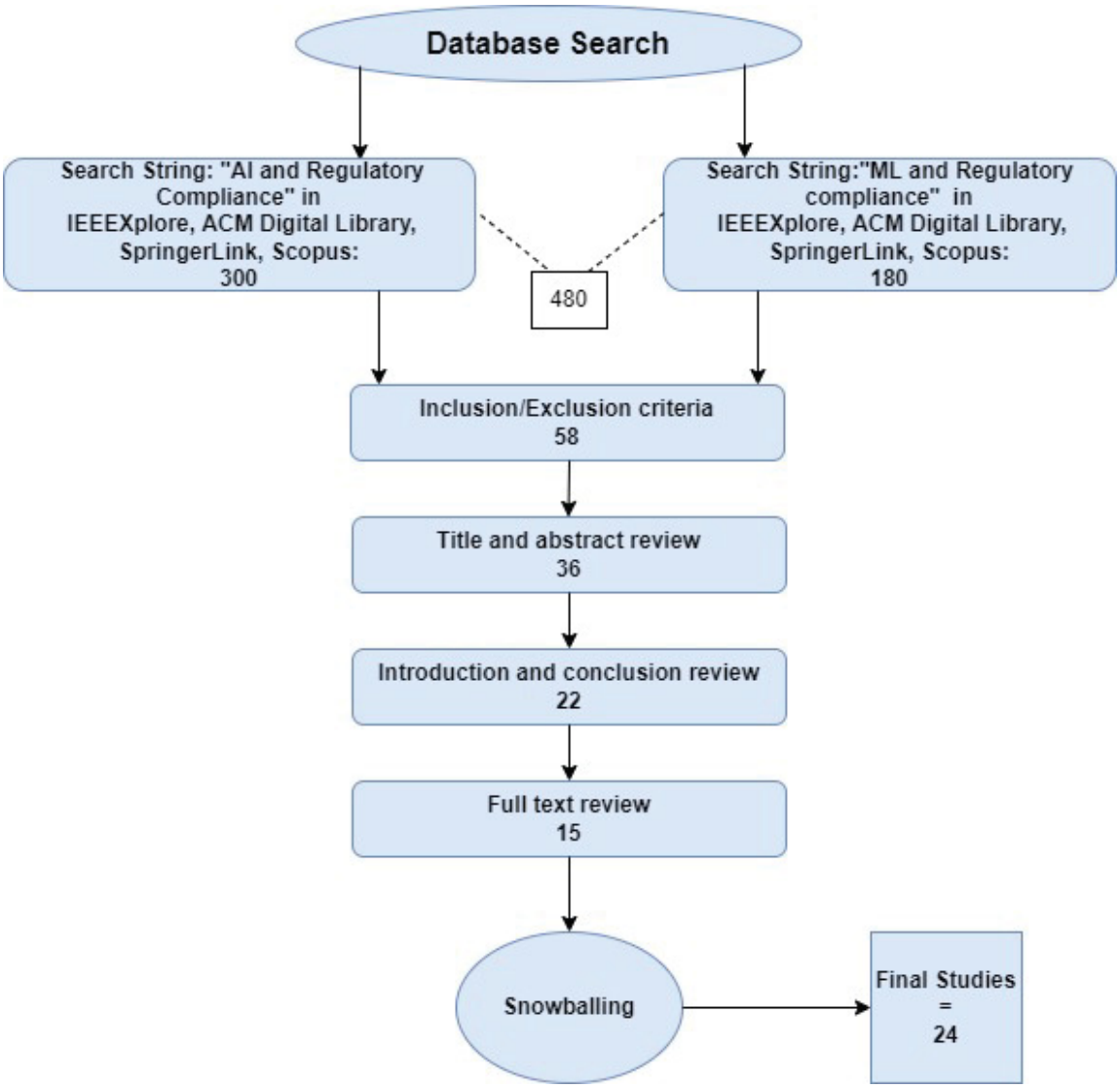


Figure 4.1: Selection of Primary Studies

24 primary studies were identified for this research. After conducting the database search, we have imported the details of each study into Google Sheets and selected

the related ones based on Inclusion/Exclusion criteria according to the guidelines by Kitchenham[30]. (Appendix A) We have conducted the forward/backward snowballing for the remaining studies to find other related papers extracted from the references and citations. Finally, after reviewing the final papers, we obtained the related data to answer RQ1 and its RQ2. The following paragraphs indicate the results from SLR.

4.2 Analysis of Literature Review

We analyzed the literature regarding the various AI/ ML approaches that have been applied for automating regulatory compliance. The extracted Machine Learning approaches are listed in Table 4.2 with their benefits and also limitations in table 4.3. Since many studies in the conducted SLR have applied a risk assessment framework for regulatory compliance management, this critical context is investigated in a separate part in detail.
In order to collect related Machine Learning approaches we conducted database search (IEEE, ACM Digital Library, Springer Link, Scopus) to find the primary studies on the topic of AI/ML and regulatory compliance and then extracted relevant studies through the forward and backward snowballing. The list of primary studies as the start set of snowballing is shown in the following table.

Title	Year	Ref.
Basic Structure on Artificial Intelligence: A Revolution in Risk Management and Compliance	2020	[9]
A Machine Learning Approach for Tracing Regulatory Codes to Product Specific Requirements	2010	[14]
Informed Active Learning to Aid Domain Experts in Modeling Compliance	2016	[48]
Information Extraction of Regulatory Enforcement Actions: From Anti-Money Laundering Compliance to Countering Terrorism Finance	2015	[40]
Towards a Regulator-Oriented Regulatory Intelligence Framework	2016	[3]
Cognitive Compliance: Analyze, Monitor and Enforce Compliance in the Cloud	2019	[1]
Research on Compliance Supervision Data Analysis Model Based on Mass Chat Records in the Inter-Bank Market	2021	[50]
Towards a Requirements-driven Workbench for Supporting Software Certification and Accreditation	2007	[32]
Supervised Key Terms Clustering for Regulatory Monitoring	2019	[53]
A Type-2 Fuzzy Logic Approach to Explainable AI for regulatory compliance, fair customer outcomes and market stability in the Global Financial Sector	2020	[2]

Table 4.1: Primary studies on AI/ML approaches for regulatory compliance

AI/ML Approach	Ref.	Benefits
Risk Framework	[9]	-Artificial intelligence allows incorporating dynamic large-scale data to indicate other identified risk factors. -The prediction process helps deliver better customer satisfaction and service, improve operational efficiency and compete with competitors
Neural Networks based Word Embedding technique called Word2Vec	[17]	-Building software systems to incorporate the values that laws are followed in spirit. -To facilitate the disambiguation by applying Deep Learning to integrate information from multiple sources, summarizing it, and augmenting the regulatory text with the additional information.
Federated Machine Learning (Risk Framework)	[38]	This study provides an establishment of continuous user authentication based on ML model trained by an organized peer-to-peer federation involving different organizations that is underpinned

vector space model, probabilistic network (PN) models, and latent semantic indexing (LSI)	[14]	trace-retrieval methods could significantly reduce the human effort and increase the accuracy of tracing regulatory codes.
Classification with NL (use natural language processing (NLP) and machine learning (ML) techniques to extract the rules from legal natural language (NL) texts in a semi-automated manner	[48]	This, along with the fact that our approach the proposed technique is rooted in generic techniques, and it can be applied to other/large regulations with equal ease.
NLP- proposed a Regulator-Oriented Regulatory Intelligence Framework	[3]	adopts a regulatory intelligence approach that involves the use of data and takes advantage of the capabilities of existing Business Intelligence and analytical tools
3-layer Neural Network, k-Nearest-Neighbors classifier, multi-label classifiers approach - RAndom K-labELsets	[1]	enforce compliance blueprints in the cloud
Type 2 Fuzzy Logic	[2]	High capablity of deriving human-understandable interpretations of the factors underlying the decision-making of the algorithm

Table 4.2: AI/ML approaches extracted from Studies

Challenge description	Ref.
-There are limitations about effective data management practices, accountability, and lack of requisite skills inside organizations. -Lack of AI knowledge in the board and senior management teams will create the possible risks from AI specialists team for their understanding of applying AI in regulatory perspectives. -Big data volumes and advanced algorithms need powerful capabilities for processing. -AI technology is expressive to implement. It needs trained and talented employees. -Its dependency on machine technology makes the human's life inactive.	[9]
ML approaches are time-consuming for training a supervised model that requires annotating a substantial amount of ground truth data	[40]
Lack of employee training. Poorly implemented physical, technical and Administrative safeguards. Limited understanding of consent and authorization based regulations.	[17]
Machine learning challenges like multivariate analysis, clustering, and classification in consumer product regulation documentations. (This study applied correlation matrix for data clustering)	[53]
The training of powerful ML models requires large amounts of data, which are often not available within a single organization.	[38]
Mining and analyzing massive amounts of data are generated in the process of electronic information in the financial sector and use them for compliance supervision	[50]
Lack of specific guidelines to utilize the evidences gathered for requirements specification for performing security risk assessment	[32]
Issues of diversity in the workplace, particularly in data and technology-focused areas	[2]

Table 4.3: AI/ML approaches related challenges

4.2.1 Risk assessment framework for regulatory compliance

Artificial intelligence has a significant role in different types of risk management such as strategic Risk management, Compliance and Regulatory Risk Management, Operational risk management, Technology Risk, Management and Financial Risk, Management. The major role of AI for Compliance and regulatory risk management is in Legality Risk, KYC, Consumer privacy, Fair credit and lending policy[9]. There is a significant consideration to security aspect of modern web structures and machine learning (ML) models are the best solutions to analyze user behavior and to detect anomalies, to identify complex patterns and trends through the risk assessment process[38].

4.3 Results from Case study

The Case Study conducted with Port of Vordingborg yielded many results and contributed to the generation of knowledge and sharing regarding improved Compliance Management operations by incorporating prototyping approach. Applying Microsoft ® AZURE online platform and employing the prototyping method had a significant impact in obtaining the results that have been obtained in this Digital Transformation and are now presented here. Accordingly, in the C2SP project, an application is to be developed for a participating small port. As the port of Vordingborg is one of the several port pilots in which prototypes were to be developed, the model that was designed and then used for prototyping achieved this goal. Ideally, as communicated by the port of Vordingborg management, the prototype would be useful as an operational tool that could be used on a day-to-day basis to achieve savings and identify efficiencies by experimenting with configurations and policies. To reduce the exposure to legal, financial, transactional regulatory and operational risk we proposed Digital Compliance system prototype (DigiComp) incorporated into "Software as a Service" solution/approach, with a focus on port operations. The proposed DigiComp system includes the following parts:
1) Vendor management including Know-Your-Customer and Asset information management.
2) Compliance management including Sanctions screening.
3) Risk assessment process by using Machine Learning approach

The prototype was implemented in Microsoft ® AZURE platform as a web application available on the Internet by http://digicomp.azurewebsites.net/ address. For the web application framework, we decided to use freeware content management system WordPress (wordpress.org). An additional paid plugin for WordPress, RegistrationMagic, was used to implement questionnaire functionality. New code in Python programming languages were developed by using Visual Studio Code software. Database were designed by using Microsoft PowerPoint, Word, and Visio software. The database was implemented with MySQL Database technology and phpMyAdmin software. As the data sources, we have used paid membership services at Marinetraffic.com web site; the sanction lists published by The Office of Foreign Assets Control ("OFAC") of the US Department of the Treasury[1] and United Nations Security Council[2].

4.4 Analysis of Case Study

The following figure represents DigiComp structure diagram in Azure cloud platform. DigiComp consists of 3 separate servers: Web application service, Linux application service, and MySQL Database. Linux service is used specially for code implemented in python programming language.

[1]https://home.treasury.gov/
[2]https://www.un.org/securitycouncil/sanctions

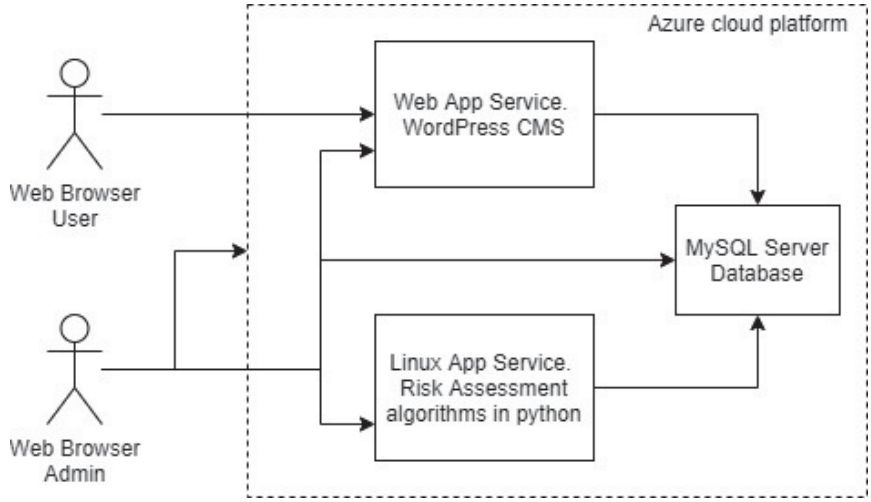


Figure 4.2: DigiComp solution structure diagram; Source: Internal project report [23]

Figure 5 represents a diagram with each role's use cases and four automatic processes within DigiComp system. Two processes import data from external data providers: marinetraffic.com and home.treasury.gov. When a new vessel is coming to arrive to port 'invite vendor' process will initiate KYC verification process for the vendor. These four processed represent the automated part of DigiComp system. We have added "Add vendor" use case for the customer actor to demonstrate how the system can be generalized to other Industries where automated data import is impossible. "Add vendor" use case allows Customer to manually add Vendor with associated asset to the list of vendors and initiate KYC verification process.

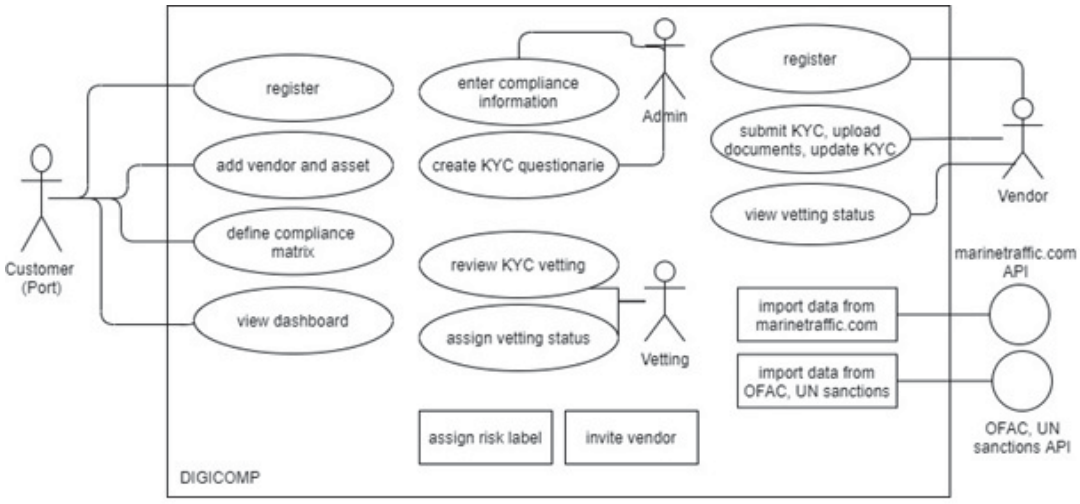


Figure 4.3: DigiComp use cases diagram; Source: Internal project report[23]

4.4.1 Risk assessment framework

This research proposes an automated platform for regulatory compliance by implementing a risk framework based on machine learning algorithms. This risk assessment predicts the future state of an entity by analyzing its compliance with required regulations and policies to minimize the events that have adverse effects on an organization, system, or business. The risk assessment process aims to reduce the likelihood that a high-risk event causes losses in a business or a system[45]. The risk assessment framework is based on Artificial Neural Networks. The framework provides risk management dashboard presented in the following table. The dashboard purpose is to display the risk associated with an incoming vessel and associated parties. Automated risk processing algorithms provides data for columns Risk and Issue. Columns Status and Vetting represent the result of KYC verification performed manually by DigiComp operators. The proposed DigiComp system in the case study ensure being complient with laws, rules and regulations help international investors and corporations of a port on establishing, expanding and operating their business within Industry. The profound understanding of Compliance Risk in this system assures to assist the ports in a committed, competent and result- oriented way. It delivers robust contracts that manage risk and allow the organisation to operate effectively and reach its strategic goals. The Digicomp system classify the new vendors into two groups Rejected or Approved through a KYC process.

Date	Vendor	Vessel	Risk	Issue	Status	Vetting
12/04/2021	Acme Inc	VesselName Commodity name(ID)	Low		Approved	
11/03/2021	ShipmentInc			ComplianceX	Pending	
01/02/2021	Firma SRL		High	SOPEP Cert	Rejected	No XX certificate provided

Table 4.4: Risk assessment dashboard

We designed an artificial neural network that can predict the risk level for each entity. The proposed Neural Network uses attributes and features as inputs to provide the output label: High-Risk or Low-risk. The training data was provided as an excel sheet that contains 699 rows to indicate 699 different possible modes for each compliance. Each Compliance means the regulatory requirements that the entity needs to comply with. The Domain Experts' knowledge have been used to discover the parameters that affect the level of risk. It helps to find the patterns in data for suspicious or high-risk vendors in the domain. The overriding concern is with the accuracy of measures. We have chosen what we can accurately measure. To find the most relevant parameters, we have conducted focus groups and interview with the domain experts, which is explained in detail in the next part. The following figures indicate the accuracy and mean squared error during training the data in the proposed risk assessment framework. (The implementation of risk framework in python

code have been attached). Epoch shows the number of training dataset in machine learning algorithm. The following line chart indicates the accuracy and MSE changes in 500 passes of the entire training dataset. The accuracy was increased during both training and validation process. MSE shows the difference between model's predictions and the ground truth and calculate its average across the whole dataset. The line chart of MSE has been declining for both training and validation data.

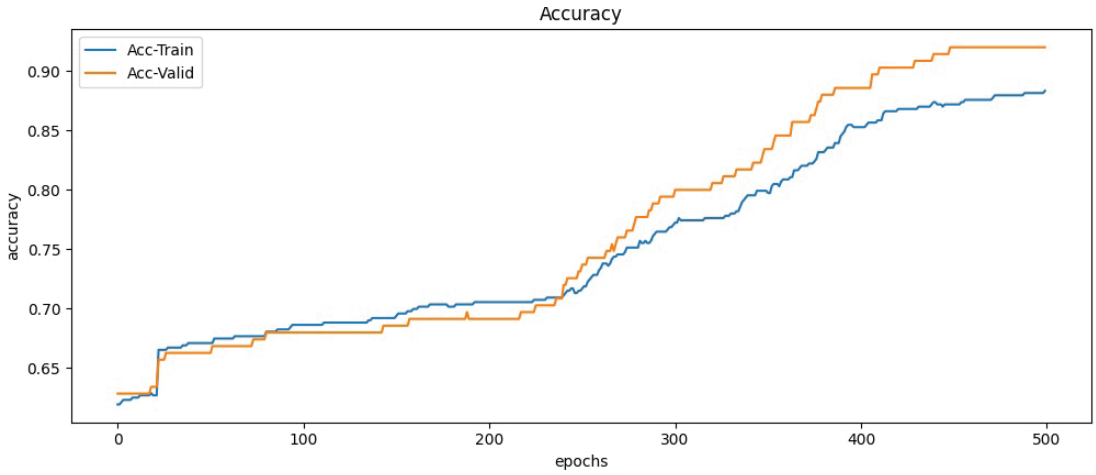


Figure 4.4: The accuracy of proposed risk assessment framework

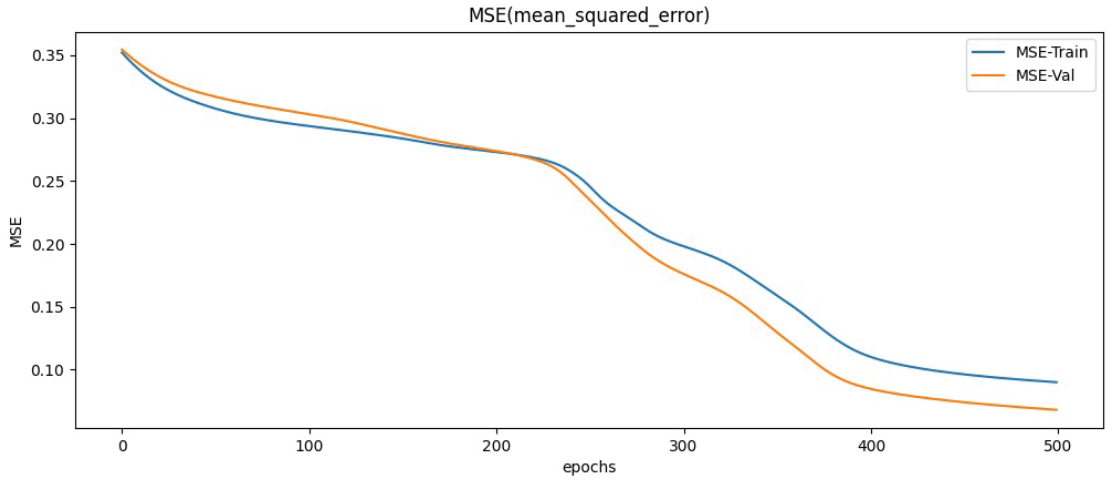


Figure 4.5: The Mean Squared Error in proposed risk assessment framework

4.4.2 The implemented Neural network

Due to regulatory concerns credit risk assessment has been the major focus of the industry. The ability to discriminate good customers from bad ones is crucial. The need for reliable models that predict defaults accurately is imperative so that the interested parties can take either preventive or corrective action[31]. Risk assessment attracted research interest from academic and industrial aspect in order to provide accurate and consistent risk evaluation to reduce the cost of non-compliance[52]. The proposed application has been tested on synthetic data. We have designed

the DigiComp system regarding the specifically required compliance based on the customer needs. Therfore we did not have a large amount of data. We started to investigate the system based on the small amount of available actual data. During normalizing the input data, a number (between 0 - 1) should be assigned to each possible mode of the parameters used as the input of Neural Network. We need to generate synthetic data based on the assumption of real data to be able to train the Neural network. Choosing the adequate feature selection method is not an easy-to-solve question, and it is necessary to check their effectiveness in different situations. The assessment of relevant features is complex in real datasets, and in some cases, the real data is not available, so using artificial data is an option[10].

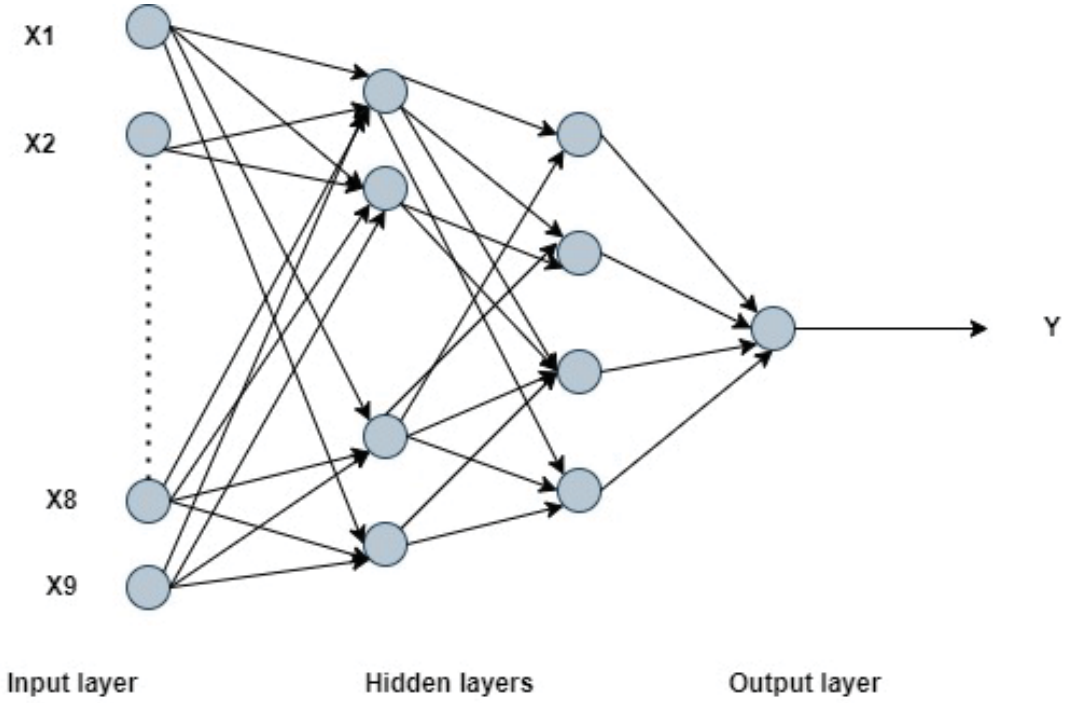


Figure 4.6: A schematic of a multilayer neural network: two hidden layers and one output layer

The neural network implemented the risk framework to predict the risk level based on the input data for each vendor. The imported excel file in the project contains the training data. It has ten columns. Columns 1 – 9 (A -I) show the input parameters of Neural Network (required compliance. Appendix B. Table B.1). the last column in the excel file (J) is the neural network output. The value of J is zero for low-risk level, and it is one for the high-risk level. The proposed neural network predicts the output based on input columns. We have generated synthesis input parameters for 699 entities to train the neural network. Therefore the excel file should be loaded in the code by using Pandas library in python and then transformed to NumPy to be readable for the neural network as Python Matrices and NumPy Arrays. We need to shuffle the data to ensure the neural network has an efficient training process and it is not only based on some specific rows with the same output. Then the rows were splited to two parts. Seventy-five percent of the rows were used as training data

and 25 percent used as validation data. The structure of neural network has two hidden layers and one output layer. A logistic Sigmoid function was applied as the activation function.

```
def activation(x):
    y = 1/(1 + np.exp(-1 * x))
    return y
```

Feed-forward network means input data should be fed to the network to generate the output in a forward direction.

```
inputs * w1 --> x1 , y1= sigmoid(x1) , y1 * w2 --> x2
    y2 = sigmoid(x2) , y2 * w3 --> x3 , y3 = sigmoid(x3) , y3 : output
```

For each neuron in the hidden layer, there is a weight from the input layer. And the activation function adds non linear to the network.

The neural network is trained during the backpropagation. Five hundred epochs or iterations were executed for training the network.

The weight adjustments to produce the highly accurate output is made through the backpropagation process.

Backpropagation:

```
def d_activation(out):
    # y = sigmoid(x) --> d_y = y * (1 - y)
    d_y = out * ( 1 - out)
    return d_y
```

The python code for the project is available in Github repository.[41]

4.4.3 Motivations for applying different tools and techniques in Case Study

Upon finalizing the specifications and requirements, a decision was taken to build a web application prototype in Azure online platform by using the "Software as a Service" (SaaS) principle. We decided to use existing web development framework WordPress and plugins for it to focus on digital compliance prototyping. The choice in selecting Azure platform and WordPress framework was based on the popularity and availability of these technologies. WordPress is open source Content Management System that allows quick prototyping for web sites with customized application logic. Azure is well documented and includes a lot of ready to use samples to implement SaaS prototype.

Motivation for applying Machine Learning algorithm: Increasing rate of new regulations and requirements and the rise in non-compliance fines is a big challenge that is time consuming and needs expensive human resource but it can be resolved by applying machine learning approaches by machine readable regulatory and policy documentation[46].

Motivation for applying Neural Network: Neural network was applied in designing the risk framework. It has a more accurate predictive analyzing compared with regression modeles. Since the neural network has the hidden layers, it can adjust the

weights based on the errors that are the difference between the target value and output value during the learning process. Therefore it has a more accurate prediction ability. Thre are only input and output nodes in the regression model; however, the learning process in the neural network is similar to the human way of learning.

4.5 Results from Focus Group and Interview

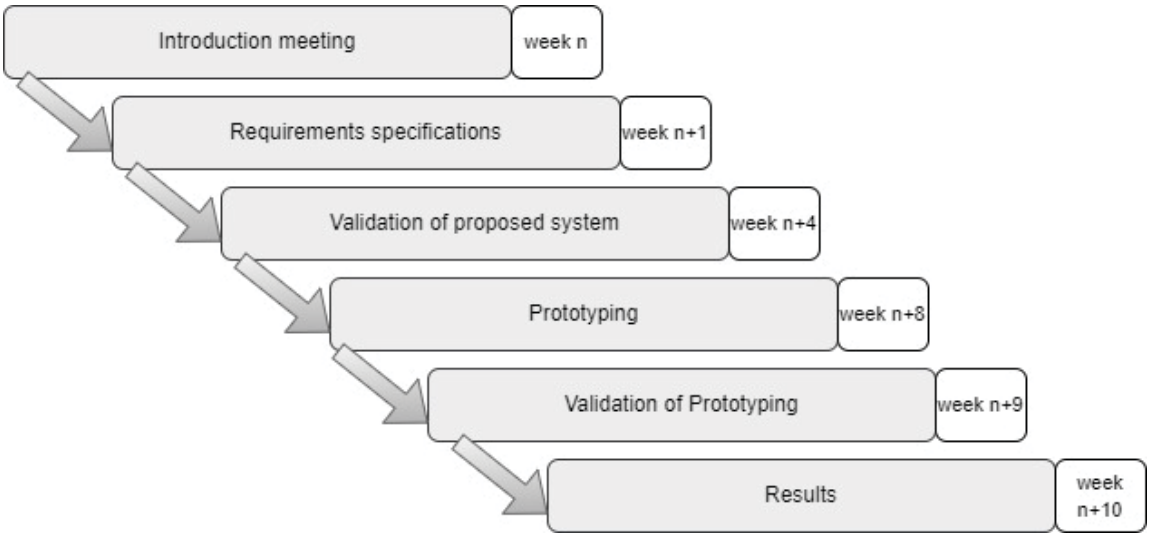


Figure 4.7: Focus Group discussion in different steps of the Case Study

1. Introduction meeting The initial meeting took place via ZOOM® due to the restrictions of the port and the COVID-19 pandemic. Upon acceptance of the port of Vordingborg, it was agreed to prepare a meetings, to clarify on what are the needs and what would be considered to help improve their condition. The following challenges were identified after the first discussions with port representatives and the existing body of research[42]:

- How can we minimize the risks of non-compliance for incoming Vessels and associated parties?
- How to integrate existing vessel tracking services with compliance management process?
- What policies, procedures, and systems can we put in place to be compliant?

2. Specifications and Requirements A Semi-structured Interview was held to understand the current compliance issues and related operations with the port of Vordingborg management for requirement specification step of developing DigiComp system. We made three presentations in which specifications about problem area were collected, refined and assumptions were made. Later, several online meetings were held with port of Vordingborg for clarifications and gathering answers to questions that we could not find. This phase was detrimental to the direction that was taken in the

pilot project. The Presentation of project goal, the questions of interview and the answers are attached to appendix C.

Upon finalizing the specifications and requirements, a decision was taken to build a web application prototype in Azure online platform by using the "Software as a Service" (SaaS) principle. We decided to use existing web development framework WordPress and plugins for it to focus on digital compliance prototyping. The choice in selecting Azure platform and WordPress framework was based on the popularity and availability of these technologies. WordPress is open source Content Management System that allows quick prototyping for web sites with customized application logic. Azure is well documented and includes a lot of ready to use samples to implement SaaS prototype.

3. Verification of Proposed System A number of digital compliance management investigations were done and then modeled into presentations given to the Port. This phase helped to filter information or processes that were not needed or necessary. In addition, the prototype features list including Risk Assessment Framework was developed and programmed in Python programming language®. The Database structure was implemented in MySQL database management software during the prototyping. This data structure greatly benefited in helping to better understand in implement digital compliance for the Port of Vordingborg.

4. Validation of Prototype To ensure that the prototype was correctly developed and that results could be used, it was deemed to have meetings with the management of Vordingborg in which their opinions and expert views were given on initial tests. This process ensured that the project and prototype results were credible and could be trusted. In addition, new knowledge was obtained in the form of testing or evaluation of digital Compliance management to ensure the identified challenges were addressed in an efficient and sustainable level.

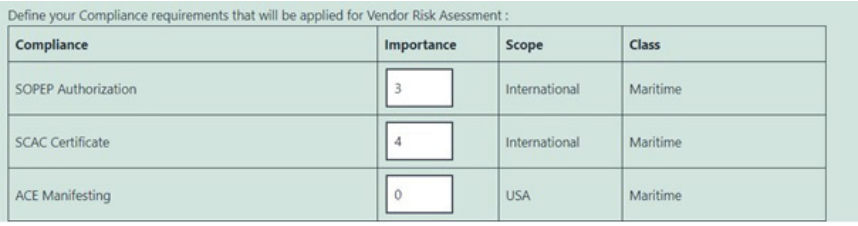
5. Results The prototyped solution was shared with the management from the Port of Vordingborg as a presentation and "web site"[3]. The results seemed to confirm their thinking, but it was very useful to have the prototype solution performed and the testing to evaluate various scenarios and policies.

4.6 Analysis of Focus Group

As mentioned in related works, there are several challenges in the Requirements specification for regulatory compliance system such as Interpretation of compliance requirements in the context of a specific product and abstractness of the compliance requirements. To find the most relevant parameters for the risk framework in our proposed Digital Compliance system, we have conducted focus groups and interview with the domain experts. The Focus Group was applied as a data collection method. The implemented artificial neural network in the risk assessment framework needs nine parameters as input to provide the related output. The gathered data from the group discussions were collected as handwritten notes and after compiling them sent to participants for verification and feedback information. The Required compliance table in Appendix B indicates the final important requirements or regulations that will use as the inputs of Neural Network in statistical format as the excel file.

[3]http://digicomp.azurewebsites.net/

In the proposed DigiComp system there is a possibility to choose the considered required compliance and its importance number.


Define your Compliance requirements that will be applied for Vendor Risk Asessment :

Compliance	Importance	Scope	Class
SOPEP Authorization	3	International	Maritime
SCAC Certificate	4	International	Maritime
ACE Manifesting	0	USA	Maritime

Figure 4.8: Screenshot of Customer Risk matrix editor from DigiComp platform http://digicomp.azurewebsites.net/

4.7 Results and Analysis of Interview

The interview was conducted to collect the data during Focus Group through questionnaire in order to specifying the requirements for developing the Digital Compliance system. The questionnaire and its related answers for requirement specification is available in Appendix C.

The answers are mapped to the benefits as the provided services by the implemented Regulatory Compliance system. Hence the proposed system was implemented based of the customer need regarding their answers to the interview questions and the discussions through Focus Group. The important answers are listed as following.

-We don't have Terminal or Port Management System . We use different systems like SAB, Outlook, Checkproof. We are looking fo a new system.

-We use Marine Traffic, but manualle (not intregrated) We would like to have a administrationsystem whereto Marine Traffic / AIS signal is connected

-50 to 60 percent ships calling at the port are new ships. Most of the ships , around 80 percent comes from owners / companies we know. The big bulkers are allways new ships, new owners.

-A couple of times pr year we have a customer/ vessel Flag from a country that you never had before But we do not actively check where the ship calling is registered.

-We do not employ Customer (BCO, Shipowner, Agency, Charterer, Vessel Operator) screening/verifications/due diligence procedures.

-We do not use a list of required information items, requested and verified for every new customer.

-We need to differentiate between customer's third parties. For example; vessel operator versus customer or customer agent identity. A port is obliged to serve incoming ships calling the Port.

The regulatory Compliance system designed based on the customer needs. The following figure shows the implemented DigiComp sequence diagram.

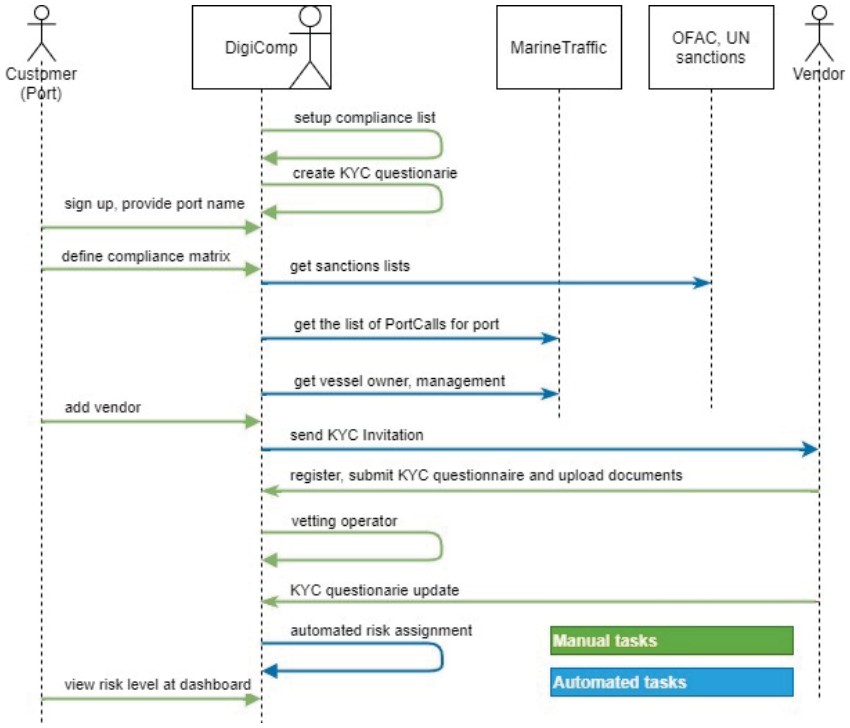


Figure 4.9: DigiComp sequence diagram; Source: Internal project report [23]

Chapter 5

Discussion and Threats to Validity

This section discusses the results to present their significance and explain the connection of provided answers for research questions. The research plan investigates the research roadmap to provide more details on the research motivation, its importance, and the relationships between the results. At the end of this section, the threats to validity are argued for each provided research methodology.

5.1 Answering the research Questions

In this study, all research questions were answered through the applied research methodologies. Figure 5.1 indicates the connections between research questions and how the answer to each question applies in the next question.

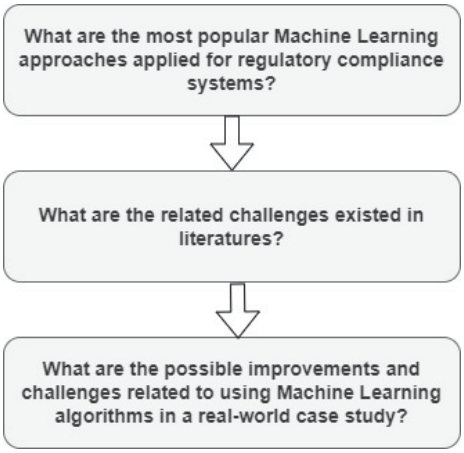


Figure 5.1: The Connection between Research Questions

5.2 Research Plan

The growth in global trading increases the growing complexity and raising many compliance issues. Thirty-seven billion dollars fines recorded due to non compliance issues for fifty-four thousands ships with 14.5 trillion yearly costs from 3 billion-plus suppliers. So here the challenge is: How can we minimize the risks of non-compliance? What procedures and systems can we put in place to be compliant? This section discusses the steps of conducting research and justifying the achieved results and findings. In this thesis work, we implemented an AI-based Digital Compliance system in Vordingborg port as the case study in an EU-financed project. The applied research methods mapped and presented along with the research questions in Figure 5.2.

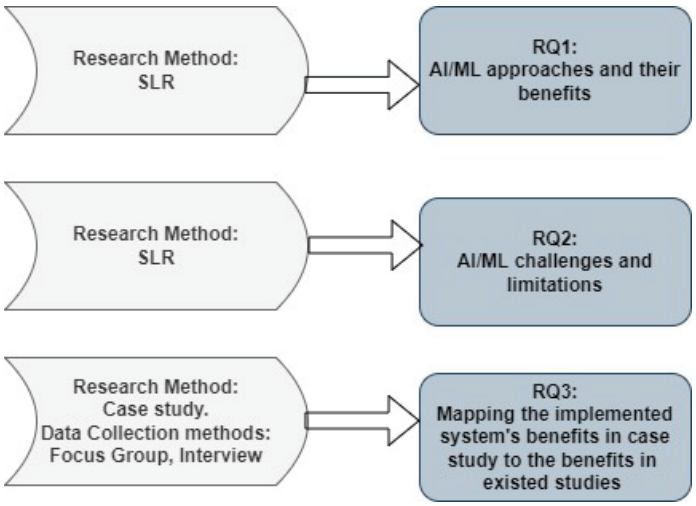


Figure 5.2: Mapping the applied research methods to RQs

This section presents the answers to research questions by applying the research methodologies in details. A systematic literature review was applied to answer this research question and the main goal was to explore the most popular Machine Learning approaches ad the related benefits and challenges. The following paragraphs present some of the same benefits and challenges that we have faced during developing an AI-based system as a case study. We mapped these benefits and challenges to the reported benefits in Table 4.2 and the challenges reported in Table 4.3 that were extracted from SLR.

Same challenges:

- There are limitations about effective data management practices, accountability, and lack of requisite skills inside organizations.
- ML approaches are time-consuming for training a supervised model that requires annotating a substantial amount of ground truth data
- The training of powerful ML models requires large amounts of data, which are often not available within a single organization

- Lack of specific guidelines to utilize the evidences gathered for requirements specification

Same benefits:

- The prediction process helps deliver better customer satisfaction and service, improve operational efficiency and compete with competitors
- Building software systems to incorporate the values that laws are followed in spirit.
- reduce the human effort and increase the accuracy of tracing regu- latory codes
- enforce compliance blueprints in the cloud

5.3 Threats to validity

This section will investigate the limitations of applied research methodologies to discuss the threats to validity for our study.
SLR: This research methodology is flexible, and it is matched with any kind of study. It has some threats and limitations, such as a lack of transparency and standard. Possible bias from the reviewer in the data extraction. One of the limitations of this method is the possibility of missing the SLRs with QRS during this review's search and selection phases. It is impossible to identify and retrieve all the relevant publications. However, our search strategy integrates manual and automated search and digital libraries and publications. After the database search, we have applied the snowballing technique to identify all related papers in the references and citations.
Case Study Sometimes the lack of scientific severity is a barrier to generalizing the results to the wide population. Researchers bias and feelings can influence the case study in some aspects. It is not easy to replicate the case study. Conducting case study is time consuming and expensive.
Interview: Interviews in empirical studies often collect data about phenomena that cannot be obtained using quantitative measures. In studies where the research goals are qualitative, it is appropriate to rely on qualitative criteria. It is a good method to use the experts knowledge and their way of thinking in a particular area. However, it is very time-consuming, and sometimes, the interviewees are not willing to dedicate their time to it. Another threat to the validity of this method is the interviewees should be selected attentively to make sure that they have enough knowledge and feel comfortable. Therefore they are willing to share their experiences with the interviewer. The quality of conducting an interview has essential effects on the quality of the results.

Chapter 6

Conclusions and Future Work

6.1 Conclusion

Enacting new anti-money laundering regulations and sanctions in different industry domains, unfortunately, raises the risk of non-compliance problems. There exists considerable pressure to make business operations or processes more efficient, safe, and transparent by applying new technologies. Digitalization of the compliance process by developing tools and methods for analyzing compliance data and providing benchmarking information for improving performance helps overcome this problem. This thesis investigated the problem by designing an AI-based regulatory compliance system using efficient and appropriate technologies.
Compliance is argued to be one of the very critical components in the Information Technology(IT) world. Often it has been observed in IT, and this has a negative inference since it generates too many documented processes involving discussions and paperwork, which unfortunately slows down the most critical work of releasing the software. By proposing to develop a Digital Compliance (DigiComp) platform, this could be a tangible solution that involves both technical and organizational challenges, which requires a large amount of research. A major challenge is the choice and design of appropriate and efficient strategies.[24]

The needs and problems of various stakeholder groups raise the challenges in modern software developments. The main challenge is in the requirement specification step.

These limitations increased when Governments and other authorities made companies comply with different regulations in different domains.

Compliance requirements play critical roles, and it will be a big problem when different customers interpret them differently.
This study has investigated applying an efficient technology in order to tackle some of these challenges. Digitalization and automation are practical in removing manual tasks in the regulatory compliance process to make it faster. Machine Learning approaches by applying human thinking more accurately help tackle many challenges and limitations. After investigating the benefits and challenges of regulatory compliance systems in different domains through reviewing previous studies, an AI-based regulatory Compliance system was implemented to explore the possible benefits and limitations in a real-world case. Some challenges can be addressed by applying decentralized technology and distributed systems. Hence, we propose a future study to design the AI-based regulatory compliance systems based on Blockchain technology.

6.2 Future work

Regulation Technology (RegTech) is one of the Distributed Ledger Technolog (DLT) use cases. A large amount of documentation needs to certify the compliance and feeling the forms takes a lot of time. DLT ensures compliance with the regulations simultaneously and immediately around all parties. The verifiable and traceable Blockchain contains the blocks, including the records of tasks, activities, and shared documents of each client, and provides the auditable resource. The verification process is done for approval or rejection of a transaction involves Machine learning algorithms and data mining. If it ia approved by all peers, it will be added to the shared ledger. As an example of leveraging Blockchain, the Decentralized Machine Learning(DML) protocol connects participants without any centralized third party, and individual devices run the DML system independently through their processing power and private datasets.[34] As a modern software development process, DevOps typically emphasizes frequent development iterations to manage the changes and quickly answer customer needs. This approach updates the AI-based system based on new regulations continuously. To develop a secure and trustable system we applied Blockchain technology as the highest and strongest data integrity standard by using the immutable distributed ledger system to add value to the business. Blockchain into the DevOps pipeline builds a tamper-proof and auditable framework that provides a secure software development environment against inside and outside attackers[6]. In order to upgrade the implemented AI-based system, it would be a good idea to apply the practices learned from Blockchain and DevOps to improve efficiency in terms of quick response to change and increase security. Blockchain helps provide an immutable and trustable system, and DevOps supports a continuous change management system to meet customers' needs quickly. DevOps applies agile principles in the development team to meet the business needs frequently and in the operational aspect to keep pace with business automation and respond to changes continuously. Constant changing regulations raise many compliance issues in international business operations, and an efficient AI-Based system is required to solve the problem. Blockchain is a distributed public ledger, acknowledged by consensus[7] that records all modifications in the DevOps pipeline as a transaction, and all stakeholders are able to see them.

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Appendix A

Data Extraction Form for SLR

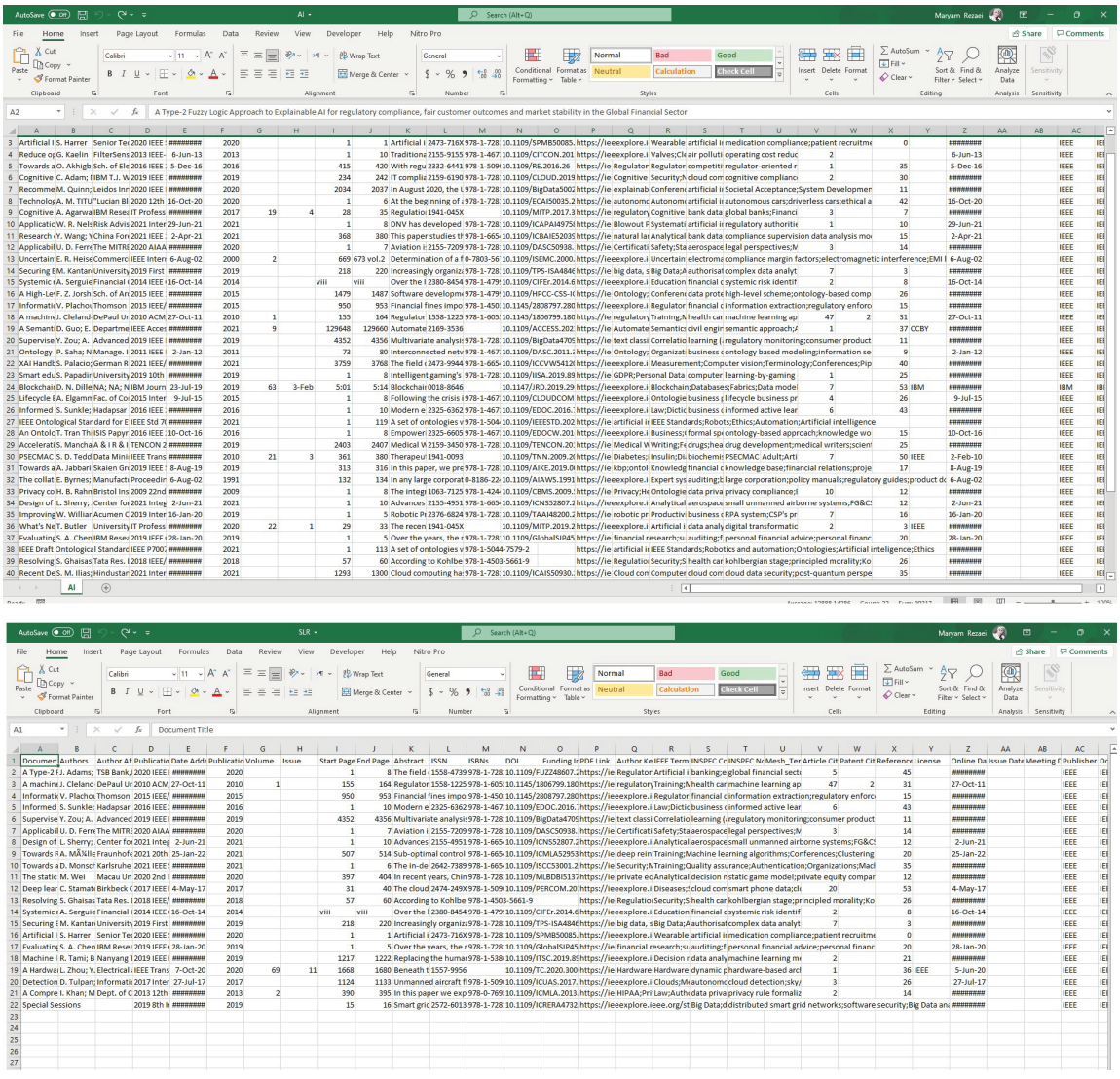

Figure A.1: Snowballing Information

Appendix B

Focus Group

ID	Required compliance	Description
1	Maritime compliance	A list of Maritime Compliance is attached in Appendix B
2	Do not exist in the US sanction list	The entity name, Registration number and residence country should not exist in the US sanction list. the sanction lists published by The Office of Foreign Assets Control ("OFAC") "https://home.treasury.gov/"
3	Do not exist in the UN sanction list	The entity name, Registration number and residence country should not exist in the United Nations sanction list. the sanction lists published by United Nations Security Council "https://www.un.org/securitycouncil/sanctions "
4	Beneficiaries checking in US sanctions	The Beneficiary's name, Registration number and residence country should not exist in the US sanction list. the sanction lists published by The Office of Foreign Assets Control ("OFAC")
5	Beneficiaries checking in UN sanctions	The Beneficiary's name, Registration number and residence country should not exist in the United Nations sanction list. the sanction lists published by United Nations
6	Bank Details	The kind of Bank account
7	Port calls	The Port Calls history from https://www.marinetraffic.com/
8	Country's Risk number	https://www.oecd.org/trade/topics/export-credits/documents/cre-crc-historical-internet-english.pdf
9	Tax ID	Trading License

Table B.1: Required Compliance (Nine Input parameters for Neural Network. The excel file import to the python code as the training and validation data)

Compliance List:

Name	Description	Scope	Class	Vetting
SOPEP Authorization	"SHIP OIL POLLUTION EMERGENCY PLAN Act to Prevent Pollution from Ships" MARPOL Annex I Regulation 37 requires every oil tanker of 150 GT and above and every ship other than an oil tanker of 400 GT and above to carry a SOPEP.	International	Maritime	Check vessel type/size and check XX YY certificate
SCAC Certificate	Standard Carrier Alpha Code is a specific code used to identify transportation companies such as freight container carriers and forwarders	International	Maritime	Check some data
ACE Manifesting	ACE is USA Customs and Border Protection's electronic manifest program. It is intended to facilitate trade while strengthening border security	USA	Maritime	Check Vessel properties Certificate
USCG Compliance	US Coast Guard Guidance Documents	USA	Maritime	uscg certificate of inspection, USCG Certificate of Compliance (USCGCOC)
USCG Certificate of Financial Responsibility	ensuing cleanup costs from spills or leaks	USA	Maritime Environment	every vessel, over 300 gross tons, certificate
MLC	Inspection of Seafarers' Working and Living Conditions (Maritime Labour Compliance)	International	Maritime Crew	Certifciate of shipboard inspection, Number of crew members
SOC	Inspection of Seafarers' Working and Living Conditions - Statement of Compliance certificate (for ships flying flag of non-ratified country or Non-enforced country - Moldova)	Moldova	Maritime Crew	Certifciate of shipboard inspection, Number of crew members
ECA, ISO 8178	"International Maritime Organisation, MARPOL emission control area (ECA) regulations. MARPOL Annex VI and the NOx - Technical Code (EIAPP-Certification) Engine International Air Pollution Prevention (EIAPP) certificate"	International	Maritime Environment	Engine emmision test according to ISO 8178, EIAPP certificate

Figure B.1: List of Maritime compliance, Source: Screenshot from Digicomp webpage

Appendix C

Interview

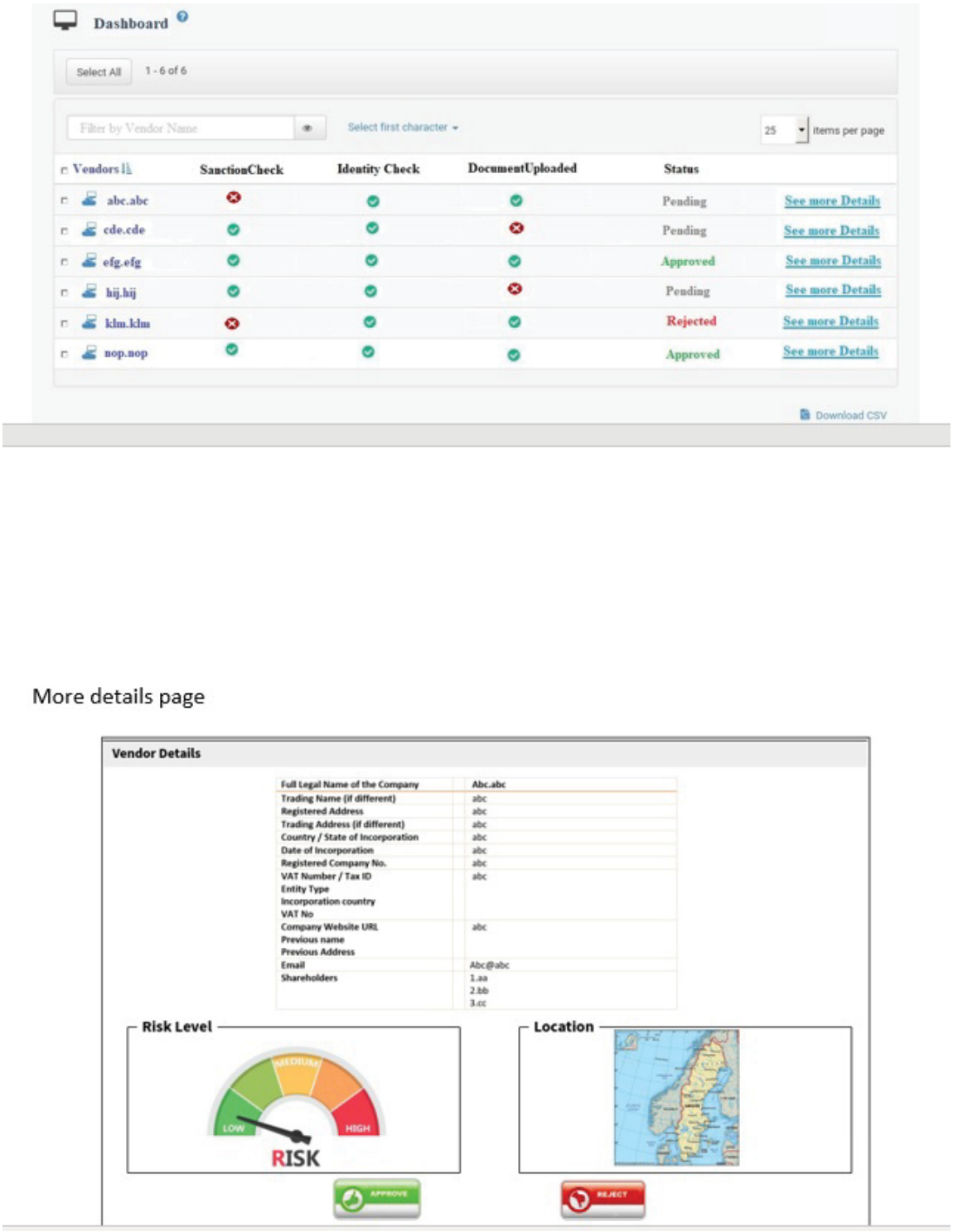

Figure C.1: Presentation of the proposed system's functionality

Phase 1: Requirements Specification

- Project Plan
- Questionnaire (*Short & Simple*)
- Next step
- Legal Consent Doc (*we follow GDPR*)

CONNECT2SMALLPORTS

2022-02-05

Interreg South Baltic | EUROPEAN UNION | European Regional Development Fund

Digital Readiness Index

Are you happy with your Terminal or Port Management System?

YES / NO

Do you use a Vessel Information System (*e.g. MarineTraffic.com?)*

YES / NO

Do you handle vessel-crew data?

YES / NO

Have you experienced any incidents related to regulations / compliance?

YES / NO

Know Your Customer (KYC) related questions

How often does a NEW Vessel call at your port? How do you track this or are notified / made aware?

How often do you have a customer / vessel Flag from a country that you never had before?

How do you employ Customer (BCO, Shipowner, Agency, Charterer, Vessel Operator) screening/verifications/due-diligence procedures? Is this process automated?

Does there exist any specific legislation, compliance or regulations that requires you to check customers eligibility? If so, can you identify them?

Know Your Customer (KYC) related questions

Who is involved in the customer verifications?

Do you use a list of required information items, requested and verified for every new customer?

If yes, who maintains / updates/publish this list?

Do you need to differentiate between customer's 3rd parties? For example; vessel operator versus customer or customer agent identity?

How many documents do you exchange before a new customer is accepted / enrolled to the system?

Rank Use-Cases by Importance

#	Use Case	Rank 1-5
1	Compliance of sanctions is conducted at your port.	
2	Listing of Forms/Certificates/Documents types to fulfill vessel verification depending on a customer origin.	
3	Ability to maintain the status of each Document by its types for the given customer account	
4	Request and Capture missing documents on customer record in automated way or at Self Service web page.	
5	Have verification/vetting process on vessel, cargo owner, and shipment /cargo with Risk Assessment status.	

Data From Port of Vordingborg

Port and Vessel Data:

Port schedule list
Vessel name
IDNumber (VIN, IMO)
Call sign/MMSI
Vessel Type
Cargo Type

Shipper Data:

Shipper (BCO)
Consignee
Cargo owner
Charterer

Vessel Operator / Ship Owner data:

Name
Address

Capitan/Crew data:

Individual name, Entity name, Address

Answers to Interview Questionnaire for requirements specification

1. Are you happy with your Terminal or Port Management System?	We don't have one yet . We use different systems like SAB, Outlook, Checkproof. We are looking fo a new system.
2. Do you use a Vessel Information System (e.g. MarineTraffic.com?)	We use Marine Traffic, but manualle (not intregrated) We would like to have a administrationsystem whereto Marine Traffic / AIS signal is connected
3. Do you handle vessel/crew data?	No, we do not handle crew data. Ships have to report, before arrival, to SafeyNet, From here ports, agents, customs , authorities can achieve data.
4. Have you experienced any incidents related to regulations / compliance?	Not yet.
(Answer shortly or you may answer during the meeting)	
5. How often does a NEW Vessel call at your port? How do you track this or are notified / made aware?	50% - 60% ships calling at the port are new ships. Most of the ships , around 80% comes from owners / companies we know. The big bulkers are allways new ships, new owners.
6. How often do you have a customer/ vessel Flag from a country that you never had before?	A couple of times pr year. But we do not activley check where the ship caling is registrated.
7. How do you employ Customer (BCO, Shipowner, Agency, Charterer, Vessel Operator) screening/verifications/due diligence procedures? Is this process automated?	There is no process here yet.
8. Does there exist any specific legislation, compliance or regulations that requires you to check customers eligibility? If so, can you identify them?	Not that I'm aware off. Only when the Port makes specific deal / contracts than the background is checked.
9. Who is involved in the customer verifications?	attorney
10. Do you use a list of required information items, requested and verified for every new customer? If yes, who maintains / updates/publish this list?	No.
11. Do you need to differentiate between customer's 3rd parties? For example; vessel operator versus customer or customer agent identity?	A port is obliged to serve incoming ships calling the Port.

Answers to Interview Questionnaire for requirements specification

12. How many documents do you exchange before a new customer is accepted / enrolled to the system?	None at this moment.
Please Rank these Use-Cases by the level of Importance for your Port (1-5):	
1. Compliance of sanctions is conducted at your port.	1 at this moment
2. Listing of Forms/Certificates/Documents types to fulfill vessel verification depending on a customer origin.	1 at this moment
3. Ability to maintain the status of each Document by its types for the given customer account	1 at this moment
4. Request and Capture missing documents on customer record in automated way or at Self Service web page.	1 at this moment
5. Have verification/vetting process on vessel, cargo owner, and shipment /cargo with Risk Assessment status.	1 at this moment

Faculty of Computing, Blekinge Institute of Technology, 371 79 Karlskrona, Sweden