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Augmented Intelligence in Logistics

A methodology to assess the reliability of Augmented Intelligence in logistic processes

Ivan Sergievich Samsonyuk

Dissertation

presented as partial requirement for obtaining the Master Degree Program in Information Management

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
Universidade Nova de Lisboa

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AUGMENTED INTELLIGENCE IN LOGISTICS

A METHODOLOGY TO ASSESS THE RELIABILITY OF AUGMENTED INTELLIGENCE IN LOGISTIC PROCESSES

By

Ivan Samsonyuk

Master Thesis presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Information Systems and Technologies Management

Supervisor: Professor Vítor Santos, Ph.D.

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledge the Rules of Conduct and Code of Honor from the NOVA Information Management School.

Ivan Samsonyuk

Lisbon, Portugal, July 15, 2024

DEDICATION

Aos meus pais, por me puxarem sempre para cima e por terem sido o pilar fundamental durante toda a minha vida e o meu percurso académico.

Aos meus amigos, que estão ao meu lado nos bons e maus momentos, e que contribuíram, de alguma maneira, para esta dissertação.

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ABSTRACT

This thesis explores the integration of Augmented Intelligence (AuI) in logistics, aiming to enhance the collaboration between human expertise and advanced machine learning technologies. The primary objective is to develop a robust methodology for assessing the feasibility and effectiveness of AuI integration within logistics processes. The proposed methodology was evaluated through interviews with logistics and IT experts, providing insights into its practical applicability and areas for improvement. The feedback highlighted the necessity for systematic project management, thorough validation of company-specific processes, and a comprehensive understanding of existing systems and their interrelations. These insights led to recommendations for enhancing the methodology's flexibility, empirical validation, and customization to fit diverse organizational needs. The findings suggest that AuI can significantly improve decision-making, operational efficiency, and overall productivity in logistics. However, successful integration requires careful planning, continuous improvement mechanisms, and alignment with strategic business objectives. This thesis concludes with recommendations for future research, emphasizing the need for in-depth case studies, long-term impact assessments, and the development of performance metrics tailored to AuI applications in logistics. By addressing these aspects, this research contributes to the growing body of knowledge on AuI and its transformative potential in the logistics sector, paving the way for more intelligent, efficient, and adaptive logistics operations.

KEYWORDS

Logistics; Supply Chain; Augmented Intelligence; Artificial Intelligence

Sustainable Development Goals (SGD):

INDEX

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

AI	Artificial Intelligence
ANN	Artificial Neural Network
AR	Augmented Reality
AuI	Augmented Intelligence
CV	Computer Vision
DSR	Design Science Research
EDI	Electronic Data interchange
ERP	Enterprise Resource Planning
GPS	Global Positioning System
HI	Human Intelligence
ICT	Information Communication Technologies
IoT	Internet of Things
IS	Information Systems
IT	Information Technologies
MCDM	Multi Criteria Decision Model
ML	Machine Learning
NLP	Natural Language Processing
RFID	Radio Frequency Identification
RPA	Robot Process Automation
SCM	Supply Chain Management
TMS	Transport Management System
WMS	Warehouse Management System
3PL	3 Party Logistics

1. INTRODUCTION

1.1. BACKGROUND AND PROBLEM IDENTIFICATION

It has been a while since the term Logistics was applied in military context, to become one of the most important functions in the economy, and one of the core processes in Supply Chain. The evolution logistics suffered through the years has been huge and nowadays this field plays a significant role in world economy (’A. Lynn, 2019).

Logistics consists of a set of processes and many interrelated activities, where all of them must be synchronized and managed in the best possible way to deliver the expected results to meet customer demands and expectations (’Zanjirani Farahani et al., 2011).

Logistics can be described as the process of planning, implementing, and controlling the efficient flow and storage of goods, services, and information from the point of origin, manufacturer, to the point of consumption, end user, with the main objective to meet customer requirements (Gleissner & Femerling, 2013).

Some of the main activities related to logistics field are inventory management, to maintain the inventory levels optimized and have appropriated control over stock, warehousing and storage, consisting in managing the flow of goods and information inside the warehouses, as well as their organization for proper picking and packaging processes, transportation management, with appropriate route planning and transport selection (e.g., ship, plane, rail), for cost-effective and timely deliveries, order fulfillment, from receiving to delivering customer orders, and information flow management from systems like TMS (Transportation Management System), WMS (Warehouse Management System) or ERP (Enterprise Resource Planning). The operations of logistics play a very important role for many industries and ecommerce in today’s connected digital world, as logistics and its activities are the final sector between the product and the customer. With all the complexities and challenges to face and overcome, to provide the expected quality of product or service, and retain customer satisfaction and loyalty, many businesses turned to technology to help them manage all the involved processes more effectively and efficiently, to strengthen their operations, increase profitability while maintaining efficiency and meet the customer demands and expectations (Yu et al., 2016).

The delivery of the product to the final costumer, deals directly with logistics activity, which is called “the last mile”, so the perception of product quality, and consequent customer satisfaction is highly linked to logistics sector (Yu et al., 2016). The e-commerce growth and increased flow of information make the importance of real-time data insights essential in decision-making, for the performance and efficiency of logistics operations, so the integration and proper development of technologies related to logistics improvement is the main need to meet these requirements.

Information Technologies (IT) are essential for advancing and enhancing logistics processes and managing the information flow of modern transport companies. There has been substantial growth in recent years in the number of IT innovations and innovative services for transportation and warehousing, but it´s important to highlight that the first point is understand the objectives to achieve and current state of certain companies, only then select and implement appropriate technologies and information systems for effective innovation management (Malyshev et al., 2022).

For logistics, it's essential to realize and understand the current challenges they face to avoid issues creation. Inventory management, where stockouts and overstocks can lead to sales losses and increased storage costs, and demand forecasting to maintain optimal inventory levels and have the capacity to predict customer demands regarding market volatility (Yan, 2011). Technology integration, where adopting Artificial Intelligence (AI) or Internet of Things (IoT), can be very expensive and inappropriate if there are no proper conditions for their integration, adoption and qualified professionals, where employees need to have qualifications, constant training and knowledge input on how to use them, as well as to be open-minded to accept these technologies (Muthutantrige et al., 2023a). Finally, high customer expectations, where customers expect faster delivery times, service quality with accurate order fulfillment and high service standards, real time tracking and in time visibility of their order (Karcz & Ślusarczyk, 2021).

These are just a few examples of problems that arise in this sector, which are important to outline and find solutions in advance to promote operational efficiency, cost reduction and enhanced customer experience.

Current research underscores the transformative impact of digitalization in the logistics sector, with experts highlighting the incorporation of advanced technologies like AI and Augmented Intelligence (AuI), big data analytics, and cloud computing. These technologies facilitate real-time data collection, analysis, and decision-making, resulting in enhanced operational efficiency and management capabilities, being one of the main focuses in improving and enhancing logistic chain nowadays (Muthutantrige et al., 2023a).

AI is a simulation of human intelligence by computer systems, with the ability to process vast amounts of stored and real time data, providing autonomous answers and solutions without human intervention, performing tasks that typically require human intelligence, such as learning from experience, understanding natural language, recognizing patterns, solving problems, and making decisions (Min, 2010).

AI may be seen as the strongest solution for many industries in the coming years, and the most desired one. By 2030, it is expected that the global economy will add $15.7 trillion in AI investments. Many implementations have been made with integration in Supply Chain operations, automating many processes and tasks where human intervention is not needed anymore, increasing with this the concerns regarding the power AI is acquiring nowadays, especially in replacing human work labor ('De Cramer & 'Kasparov, 2021).

AuI, or Intelligence Augmentation (IA) can be seen as a strong solution in this field. As a branch of AI, consisting mainly of its techniques, focuses on enhancing human intelligence and not replacing it, where AuI technologies assist humans and provide them with proper and relevant data, complementing their abilities with advanced technology, improving so the productivity, decision-making, overall performance and problem-solving ('Xu et al., 2020).

AuI seems to be a strong solution for Logistics sector, mainly because its outcomes seem to meet logistics problems. However, it is not clear how AuI can be efficiently and effectively implemented in logistics processes, with the purpose of increasing overall efficiency, reducing costs and enhancing the management decision-making capacities.

1.2. Study Objectives

The main goal of this research consists in creating a methodology to apply to the logistics sector, verifying the truthfulness of AuI technologies application, optimizing logistic processes efficiency and increasing their interoperability, as well as verify the human-machine hybrid collaboration.

To achieve this goal, the following intermediate objectives were defined:

- Framework logistic chain and it problematic;
- Study logistics main processes and their activities;
- Study Augmented Intelligence and its components;
- Build an intelligent process model to support logistics;
- Validate the model.

1.3. Study Importance and relevance

Over time, logistics evolved from a straightforward, single-purpose support role into a complex, interconnected process encompassing all value-added stages. This development aims to enhance and streamline comprehensive operational and economic activities. Logistics plays a vital role in the economy by ensuring the efficient and effective movement of goods, services, and information from the point of origin to the point of consumption, where its economic importance can be seen through improved customer satisfaction, with delivery in time, order fulfillment accuracy and high-quality service, through cost reductions, with efficient transportation and inventory management, enhanced productivity and sustainable practices (Gleissner & Femerling, 2013b).

The focus of the logistic activities is to ensure the right product, in the right quantity, at the right quality, at the right place, at the right time, at the right cost and for the right customer, the so called seven R’s, to achieve higher levels of efficiency and stay ahead of the competition (Gleissner & Femerling, 2013b).

The implementation of AuI in logistics can make significant changes in the entire Supply Chain. By strengthening the operations and meeting customer demands, it is intended to increase business growth, optimize capabilities and interrelation in many inter-connected departments (Dargan et al., 2023).

One of the key points in any industry and business, is to have a competitive advantage against their competitors. This competitive advantage can be achieved once you join human intelligence with machine intelligence, which results in Hybrid Intelligence (HI). Since then, the competitive advantage can be achieved and can make a huge difference. Professionals are enabled with HI by being experts in their area, where they apply their business knowledge jointly with reliable, real-time information generated by machines. By saying this, decision-making options will improve not only one process, but two or more regarding the information system they have in place and the quality of disposed data (Xiang & Yu, 2023).

It´s important to understand how humans and AuI can work side by side, increasing with this the human acceptance of AI, and work towards the fast-changing client environment and respond to the constantly increasing demand, without skepticism and concerns (Bazoukis et al., 2022a).

Through this study, it’s important to understand how this methodology can positively influence logistic processes with AuI integration on them, improving the transparency between the entire logistic chain, decision-making capabilities and highlighting human centric approach.

2. LITERATURE REVIEW

2.1. Logistics Chain

2.1.1. Overview

The term logistics has many similarities within the actions taken in ancient history. The significance of logistics has been evident throughout history, particularly in overseeing notable military campaigns led by the Greek, Roman, and Alexander the Great's empires. In these historic campaigns, logistics played a crucial role in ensuring that military forces were well-supplied and capable of maintaining their operational effectiveness over extended periods and vast distances (’A. Lynn, 2019).

During World War II (WW2), efficient logistics allowed military forces to project power over great distances and sustain long-term operations, ensuring that armed forces were supplied with necessary equipment and provisions. Managing supply chains involved not only transporting goods to the front lines but also establishing supply depots, maintaining communication lines, and coordinating the movement of troops and equipment. Many principles and practices of modern logistics have their origins in military logistics. Just-in-time delivery, inventory management and warehousing were refined through military applications and subsequently adopted by commercial industries, and as we can see these concepts are part of the most important tasks in logistics sector (’Zanjirani Farahani et al., 2011).

Nowadays, logistics professionals carry out their responsibilities drawing on their expertise, experience, and knowledge. In contemporary industries, logistics managers are tasked with establishing effective and efficient logistics systems. They ensure that the correct products reach the appropriate customers, at the right time and place, and in the most cost-effective manner. In the current business landscape, logistics serves as a competitive strategy for companies, enabling them to meet customer expectations (’Zanjirani Farahani et al., 2011)

It’s important to note that logistics is not the supply chain, but one of the most important parts of it (Gibson et al., 2005). Logistics involves the planning, execution, and management of the efficient and effective movement and storage of goods, services, and related information from their origin to their destination. The goal is to meet customer requirements while minimizing overall costs (Mentzer et al., 2001)

The main processes associated with logistics play a giant role in the supply chain nowadays, which are mainly warehousing, inventory control, picking and packaging, transportation, and information management, all of them being strongly dependent on each other. Managers in front of logistics department have the obligation to assure that all the related processes and activities of this sector are adjusted to current and fast developing reality, as well as constant improvement to be ahead of the competitors and be able to deliver the right product to the right customers in the right time, with operational and cost-effective manner (RISTOVSKA et al., 2017).

Logistics processes vary widely from company to company, so organizations use process frameworks to simplify and clarify them. A process framework groups related processes into categories, often based on value chains. This approach helps provide a clear understanding of the processes, showing how they are structured, how they work together, and how they achieve goals. To create metrics and evaluate performance in any process, including logistics, it's essential to first understand the process and its connection to the enterprise. To aid organizations in adopting process-based thinking, APQC has developed the Process Classification Framework (PCF) (APQC. 2024, 2024).

Manage logistics and warehousing (10219)			
Provide logistics governance (10338)	***Plan and manage inbound material flow (20936)***	***Operate warehousing (10353)***	***Operate outbound transportation (10341)***
Translate customer service requirements into logistics requirements (10343)	Plan inbound material receipts (10349)	Manage and track inventory deployment (10353)	Plan, transport, and deliver outbound product (10360)
Design logistics network (10344)	Manage inbound material flow (10350)	Receive, inspect, and store inbound deliveries (10354)	
Communicate outsourcing needs (10345)	Monitor inbound delivery performance (10351)	Track product availability (10355)	Track carrier delivery performance (10361)
Develop and maintain delivery service policy (10346)	Manage flow of returned products (10352)	Pick, pack, and ship product for delivery (10356)	
Optimize transportation schedules and costs (10347)	Control quality of returned parts (12708)	Track inventory accuracy (10357)	Manage transportation fleet (10362)
Define key performance measures (10348)	Salvage or repair returned products (20109)	Track third-party logistics storage and shipping performance (10358)	
Define reverse logistics strategy (16905)	Perform salvage activities (10366)	Manage physical finished goods inventory (10359)	Process and audit carrier invoices and documents (10363)
	Manage repair/refurbishment and return to customer/stock (14195)	Manage warehouse transfers (20957)	

Figure 1- APQC PCF for Logistic Processes (APQC. 2024, 2024)

The global markets are growing, as well as the demand for personalized products and services, and to assure business growth and prosperity, the upfront entities need to realize the importance of adopting smart solutions and interconnected supply chain and logistics (Izmailova et al., 2018).

2.1.2. Technologies on the service of Logistics

Technology has profoundly changed the way logistics operations are carried out. The adoption of technology and information systems have enabled great capabilities and improvements in logistics, increasing and recognizing the importance it has for the business growth and service quality (RISTOVSKA et al., 2017).

We are currently living in the 4th industrial revolution, which is characterized by the integration of Information and Communication Technologies (ICT) in the whole Industry 4.0 chain, where all the associated entities connected through the Internet, and logistics is equally important in this equation. Data is collected through real world components and machines, which is organized, processed, analyzed, and converted into valuable information through cyber physical systems, and finally provided through virtual world for use and application (Winkelhaus & Grosse, 2020).

Logistics has at its disposal technologies which include a variety of advanced tools and systems designed to improve efficiency, accuracy, and overall effectiveness. Conventional technologies are still relevant for the logistic chain and have a wide implementation among many industrial sectors. These technologies include Enterprise Resource Planning (ERP), allows a unified view of operations, by integrating diverse business processes such as inventory management, procurement and order fulfillment, enhancing decision making and operational efficiency through real-time data access; the Warehouse Management System (WMS), a software where it's possible to gain visibility into warehouse operations, allowing to efficiently manage locations and inventory levels, automate warehouse processes, starting by receiving products to shipping them, enhancing efficiency and reducing errors; Transport Management System (TMS) which gives the possibility for route optimization planning, with delivery times improvement and cost reduction, and freight management movement. Global Positioning Systems (GPS), Radio Frequency Identification (RFID), Electronic Data Interchange (EDI), Forecasting, among others (Cano et al., 2021). These technologies have transformed the industry by optimizing processes, boosting efficiency, and enhancing overall supply chain performance.

Disruptive technologies have played a pivotal role in reshaping logistics operations. The use of advanced technologies such as Internet of Things (IoT), Artificial Intelligence (AI), and Big Data Analytics (Muthutantrige et al., 2023b), as well as Augmented Reality (AR), Blockchain Technology and cloud computing (Cano et al., 2021), enable real-time tracking and monitoring of shipments, predictive maintenance for vehicles and equipment, and data-driven intelligent decision-making, allowing digital platforms and systems the integration and collaboration among various stakeholders in the logistics ecosystem. These technologies enable companies to easily connect with suppliers, carriers, and customers, facilitating streamlined communication, data sharing, and coordination. Figure 2 shows the current technology systems applicated to the core processes of logistics.

APQC Processes / Technologies	Logistics Governance	Inbound Logistics	Warehouse Logistics	Outbound Logistics
Big Data Analytics	✓	✓	✓	✓
Augmented Reality			✓	
Blockchain Technology	✓	✓	✓	✓
Cloud Services	✓	✓	✓	✓
Drones				✓
EDI	✓	✓	✓	✓
ERP	✓	✓	✓	✓
WMS	✓		✓	✓
TMS	✓			✓
IoT		✓	✓	✓
RFID		✓	✓	✓
By Voice			✓	
Wearable Technologies			✓	✓
S&OP	✓			
CPFR	✓	✓	✓	✓
GPS				✓

Figure 2- Systems for Logistics Processes (Cano et al., 2021)

Automation brought a completely new image to the logistic chain, especially in the warehouse environment. A good example is the Integrated Logistic Platform (ILP 4.0), a software architectural model that encompasses all the logistical phases in an integrated manner to improve the coordination between all the processes and provide solid interactions, solve many constrains and problems, such as security or theft of the goods, improving the storage field and goods quality, increasing the efficiency through this unique and cross-functional system (Capua et al., 2023).

The acquisition of raw data provided by many automated sources mentioned before, gives access to dig data analytics, leading to the use of cloud computing systems, which gives many advantages and reinforcements to logistic chains by giving quick and efficient access to IT and providing innovative solutions (Yalcin & Daim, 2022a).

The use of digital platforms and information exchange gives the possibility for cross-departmental as well as inter-organizational collaboration between shareholders to mutually support common processes such as transportation, to maximize the benefits and available resources (Abideen et al., 2023).

2.1.3. Challenges and Opportunities

There are no doubts about the importance that logistics have on the supply chain nowadays. Besides the constantly growing worldwide demand and the importance of this field in the past decades, the pandemic showed that if businesses don't stand side by side with progress and current innovations, they will struggle and be left behind against their competitors. The use of technology and information systems such as AI, automated robots, IoT, among others, enables businesses to answer the increase of the international trade volume and the e-commerce growth (Yalcin & Daim, 2022).

Another important aspect, besides acquiring new customers, is retaining the existing ones as a major factor for long term company success, and to accomplish this, companies need to deliver what is expected from them, through efficient logistic management and optimized capabilities (Kumar et al., 2022).

To accomplish these goals, the integration of disruptive technologies in current logistics is a must to stay in line with current tendence of digital world and handling the increased complexities in the sector. The main constraints consist in the associated integration cost of such technologies, the available resources, human resources and material, to properly adopt them and the acceptance of the labor. Many believe that human work-labor will be totally replaced with intelligent systems integration, especially the ones related to AI, but it's important to realize that there is another way of solving and achieving mutual advantages and common goals ('De Cramer & 'Kasparov, 2021)

There are endless opportunities and advantages in logistics with the integration of Information Systems (IS) and disruptive technologies, such as improvement of all processes and enable their interrelationships, real time information exchange and access to all the resource for taking assertive decisions and improving overall business performance and the access of contemporary technologies for processing and analyzing large quantities of data to provide valuable insights and information (Facchini et al., 2019). But to accomplish successfully these goals, it's important to understand the current situation of the company, their capabilities and stay realistic about the possibility of the integration of such complex systems.

2.2. AUGMENTED INTELLIGENCE

2.2.1. Concepts

AI researchers define intelligence as “the ability to achieve goals in a wide range of environments”. AuI focuses on enhancing human cognitive abilities through collaboration with machines (Velankar et al., 2024).

Unlike AI, which seeks to create autonomous systems that perform tasks without human intervention, AuI aims to complement and amplify human decision-making, creativity, and problem-solving capabilities. This approach leverages AuI and other advanced technologies to provide insights, recommendations, and support, enabling humans to make better, more informed decisions. The goal is to foster a collaborative interaction between humans and machines, where technology assists and augments human intelligence rather than replacing it (Sadiku & Musa, 2021).

AI and AuI are two distinct approaches used to achieving similar objectives. AI is designed to perform tasks autonomously, whereas AuI works alongside humans to enhance and supplement human intelligence. The primary difference between AI and AuI is that AI automates tasks requiring human intelligence, while AuI enhances human decision-making. AI systems make decisions based on data sets and predefined rules, while AuI employs machine learning and predictive analytics to improve human decision-making and subsequent actions (Dave & Mandvikar, 2023). Figure 3 shows illustrate main differences between AI and AuI.

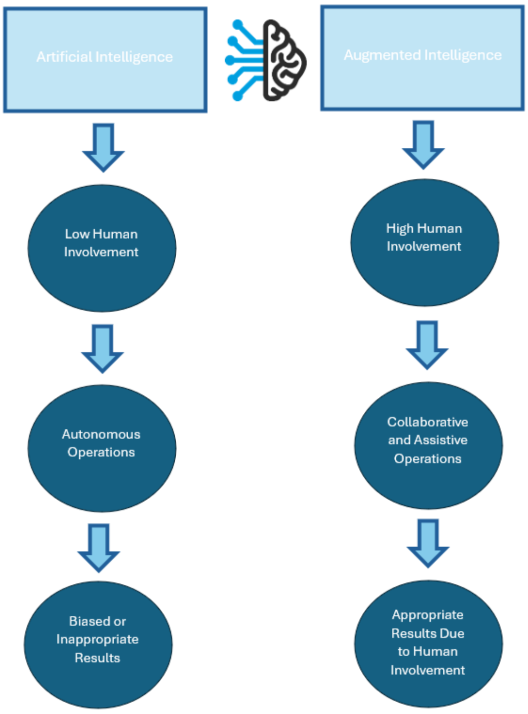

Figure 3- Difference between AI and AuI (Dave & Mandvikar, 2023).

AI and AuI share many components and tools, as AuI is built upon the foundation of traditional AI. However, their focus and application can differ. The common ones between both features are Machine Learning (ML), Natural Language Processing (NLP), Robotic Process Automation (RPA), Computer Vision (CV) and Big Data Analytics. Even though AI and AuI use the same tools, they serve different purposes. For example, AI utilizes Big Data analytics to analyze vast amounts of data to find patterns, make predictions, and drive automation, while AuI uses data analytics to provide actionable insights and support human decision-making, or when utilizing CV, AI uses machines to interpret and process visual information from the real world, and instead, AuI enhances human knowledge by providing real-time visual data analysis, such as in medical imaging or quality control in production sector (Sadiku & Musa, 2021).

With this, the main point is to understand that AI and AuI have different focus and application, being AI focused on performing tasks automatically without human intervention, applied in cases with completely automated activities, while AuI emphasizes collaboration, used in contexts where human unique qualities, mainly intuition, creativity and expertise are essential ('Xu et al., 2020).

AuI plays an assistive role in improving human decision-making, by giving insights on complex data that is analyzed, organized, and synthesized in concrete and well-structured information, enhancing their capabilities and the existing skills to make better and assertive decisions, which leads to the strengthening of the associated businesses, meeting customer's demand and expectations and the future trends (Hurwitz et al., 2019).

The beauty of AuI relies on the power to increase and assist human intelligence, and not replacing it with an artificial one, giving them the capacity to manage well-organized and precise data to make better and informed decisions to increase business efficiency and providing a high-quality outcome, creating a strong human-machines relationship, and a promising future (Yau et al., 2021).

2.2.2. Approaches and strategies

AuI is the next level in AI and is one of the most important emerging technologies, where the word "augmented" means "to improve" (Sadiku et al., 2021).

In simple terms, AuI can be defined as the sum of 50% of HI with 50% of AI. Three main roles can be defined by HI and AI in AuI. The first one is HI-AI approach, where HI provides initial inputs to the AI decision-making engine, enhancing the system's context awareness and accuracy. Second one is the AI-HI approach, AI generates knowledge and offers guidance to humans in decision-making, improving the accuracy of their decisions. Finally, the third approach combines HI and AI decisions, where both human and AI inputs are considered together to make the final decisions. (Yau et al., 2021).

HI and AI have different strengths and weaknesses, where to complement each other, they must be combined in the proper way. HI strength consists in creativity, empathy, common sense, flexibility and the capacity of annotating arbitrary data, while AI enhances better speed and efficiency, pattern recognition, strong analysis capacity and consistency, the combination of intuitive and analytic capacities creates strong synergies and possibilities for results achievement (Dellermann et al., 2019).

The main point of the AuI is enabling a hybrid approach where humans and machines work together towards que same goals and objectives, by augmenting human capabilities and not replacing them. While AuI analyzes data and provide structured patterns, humans by their side need to utilize intuition, imagination and have knowledge about the related field, enabling them to make accurate decisions due to the emotional associations and judgments, something that AI is not capable of (Dellermann et al., 2019).

To accomplish common objectives, humans and machines form a collaborative team where tasks act as the focus of their partnership, while humans and machines themselves are the participants. Tasks are central elements, encompassing identification, reasoning, prediction, and action. Human cognitive processes include perception, attention, memory, reasoning, judgment, decision-making, and problem-solving. In contrast, machines follow a cognitive process involving information acquisition, data processing and representation, reasoning, optimization, decision-making, and action. Tasks within each stage of these cognitive processes can be categorized into the intention layer (goal layer), reasoning layer, decision layer, and action layer. Once the task and its core elements are detailed, the four levels of humans and machines are aligned to ensure mutual understanding of each function and its significance (Dave & Mandvikar, 2023).

Human	Task	Machine
1. Perception / Attention	*Identification*	*1. Information Acquisition*
2. Memory / Reasoning	*Reasoning*	*2. Data Processing & Representation / Reasoning*
3. Judgment / Decision-Making	*Prediction / Decision-Making*	*3. Optimization / Decision-Making*
4. Problem Solving	*Action*	*4. Action*

Figure 4- Human-Machine Hybrid Collaboration Model (Dave & Mandvikar, 2023).

AI evolves by replicating human behavior and utilizing techniques that exceed human analytical capabilities. It performs exceptionally well in specific tasks with clear objectives and measurable outcomes. Nevertheless, AI cannot emulate the implicit human abilities of wisdom, insight, and intuition. Also referred to as machine intelligence or computer intelligence, AI has made remarkable progress, often outperforming humans in repetitive and objective tasks. Despite this, it remains inadequate in complex scenarios involving emotions, intentions, and uncertainties. Future advancements in intelligent science are anticipated to merge the strengths of machine intelligence with human wisdom, resulting in a human-machine hybrid known as augmented intelligence, "to improve" both humans and machines working conditions, leading to optimal solutions and desired outputs (Xiang & Yu, 2023)

The future will demand a new type of hybrid business professional—someone who merges business acumen with data expertise to create predictive models that inform intelligent decision-making. This new breed of professionals will be essential for integrating business knowledge with the ability to utilize data for making smart decisions. It is expected that top management leaders with superior decision capacities understand these necessities and create proper integration plans. It is expected that the organization's leaders will be able to convey and implement this new work ethic, create an environment of mutual collaboration and favorable to the acceptance of augmented intelligence by the workers, and help them understand the advantages and importance of this synergy for the desired outcomes, as well as the company's progress and development (Hurwitz et al., 2019).

To achieve these measures, AuI implementation should be implemented according to the following steps (Hurwitz et al., 2019):

• Decide whether to change the business process and task flow for human machine cooperation to drive better outcomes

• Select which tasks and decisions within the business process to automate

• Determine the proper AI tools

• Determine what data to acquire to better understand and model the business and customers

• Build the data models

• Test the results for reliability and accuracy

Disruptive technology always takes time to be properly accepted, and it takes a while to recognize its true value and importance. To effectively integrate different AuI tools and make workers understand their importance and acceptance, making the organization work and progress in an efficient way, ('De Cramer & 'Kasparov, 2021) define a three-step approach, where:

- 1st step: teams will increasingly include both humans and machines working side by side. This shift carries the risk that biases and stereotypes could affect decisions and teamwork. Machines, as non-human co-workers, might be met with distrust, leading humans to share less information and avoid collaboration, what will affect the pre-defined work ethics. Team leaders must be skilled in addressing these negative dynamics and trained to understand the impact of such biases.
- 2nd step: future teams, combining humans and machines, will require leaders skilled in uniting diverse parties. Creating inclusive teams that integrate man and machine will be essential. Leaders must train to become experts in coordinating and coaching these new diverse teams to achieve better performance.
- 3rd step: Effective management of team processes will require human oversight. Humans must be educated on how AI works and its applications, using their judgment to align the strengths and weaknesses of both man and machine. This will ensure AI is used optimally to enhance performance and serve human interests.

To go along with progress and be ahead of competition, understanding the context of provided data and making right associations is essential to ensure progress, by knowing all the nuances associated to the field in question. Machines are quite good in analyzing huge datasets. AuI has a huge power and influence on what businesses may acquire in today's connected world. It is possible to know almost everything about the customers (Yau et al., 2021).

AuI systems need access to large, high-quality data sets to make accurate predictions. To apply it effectively, it's crucial to assess the availability and quality of relevant data. This data must be ingested, prepared, and validated. Continuous learning requires feeding the model with sufficient and timely data, as the system's performance depends on the data it contains (Hurwitz et al., 2019).

2.2.3. Augmented Intelligence in business

Despite being relatively a recent topic, AuI has already been applied successfully and it's gaining increased relevance and importance due to its supportive features to enhance human capabilities and improve decision-making, but most importantly, by supporting the principle of collaborative intelligence between humans and machines (Zheng et al., 2017).

AuI has been utilized in diverse fields, including healthcare, education, and finance. In healthcare, AuI aids medical professionals in diagnosing diseases by analyzing medical images and patient data. It highlights potential issues or patterns, allowing doctors to make more informed decisions more quickly. This collaboration between AI and human expertise not only enhances diagnostic accuracy but also frees healthcare professionals to concentrate on patient care and empathy, areas where human judgment and communication are indispensable (Dave & Mandvikar, 2023). These supportive techniques lead to improvement of diagnosis accuracy, disease detection in the early stages and psychological patterns (Bazoukis et al., 2022b) as well as early cancer detection, such as skin (Dargan et al., 2023b).

There are already applications of AuI on industry and manufacturing systems, to enhance the production of quality products and lower their price. The creation of new product design, improving human creativity by giving proper inputs, packaging improvements by optimizing empty spaces, and fault detection and the root that caused them, notifying human operators to take measures ensuring that operations are back to normal flow (Yau et al., 2021).

The car industry is another example where AuI enhances self-driving cars by combining AI with human expertise. It integrates data from sensors like cameras, LiDAR, radar, and GPS to understand the vehicle's surroundings. Humans play a key role in designing algorithms, making decisions in complex situations, and labeling data sets for machine learning, improving the system's recognition and response capabilities (Chamola et al., 2024).

In education, AuI improves decision-making by handling large amounts of data and removing issues like fatigue and attention lapses that can cause misinterpretation (Velankar et al., 2024).

In the financial sector, AuI is introduced as a collaborative approach to help in the regulation of AI, due to the complexity and autonomous functions, to gain the trust and confidence of the users by not replacing the human mind (Lui & Lamb, 2018).

The interest in AuI has been growing during the past years, but it's still a recent topic, so at this point an important emerging technology, which includes AI, machine learning, and neural networks, is set to transform how companies and people work in the near future (Dave & Mandvikar, 2023).

2.3. Logistics & Augmented Intelligence

According to top innovation trends in the field of logistics, AuI and AI are positioned in the first place as the innovation technology to be applied in the field, with the expectation to highly increase the productivity and efficiency of overall processes, by combining human knowledge and business expertise with machine fast processing of large amounts of data in real-time and fast manner (’Karlouski & ’Larchenok, 2020).

Through previous literature review, it was intended to understand the concept of logistics and AuI, their importance nowadays, as well as current world applications.

There are already AI applications in the field of logistics and supply chain, such as optimizing logistics warehousing operations and distributions paths through intelligent systems (Gong, 2022), improvements in container route transportation and dispatching modes (’Xu et al., 2020),but there were almost no references found regarding the integration of AuI in logistics.

As previously explained, it is intended to verify the trustworthiness application of AuI in the logistics sector, as this innovation trend seems to be a great solution to many constraints and headaches of logistics field. As a novelty and recent topic, more deep research is to be done to extract maximum information and details regarding the current point of AuI integration in logistics, where the PRISMA methodology will be used.

PRISMA means *“Preferred Reposting Items for Systematic Reviews and META-Analysis”,* used to conduct systematic literature reviews and meta-analyses through a set of guidelines. PRISMA was developed to help authors in their research by providing a wide array of systematic reviews (Moher et al., 2010)

2.3.1. **PRISMA Methodology**

Previously, the topics presented on the literature review served to clarify and understand the theoretical background of logistics and AuI, as well as their possible compatibility.

In this section it will be performed a systematic literature review using PRISMA method, to understand the most recent application and use of AuI in logistics, to retrieve all the scientific literature that could help the following research questions:

SLRQ1	What is the current state of AuI in logistics?
SLRQ2	What are the major constraints of AuI integration in the logistics chain?
SLRQ3	How can the challenges for logistics be solved by the implementation of AuI?
SLRQ4	What kind of AuI techniques are currently useful in this area?
SLRQ5	What are the advantages and disadvantages in applying AuI techniques in this field?

Table 1- Systematic Review's Research Questions

To answer these questions, it was important to understand the most relevant concepts in the presented literature review and the studies in this field. Specific keywords were carefully selected to proceed with the search to retrieve available scientific studies and articles for the presented topics.

	Logistics	**Augmented Intelligence**
Keywords	Logistics	Augmented Intelligence
	Supply Chain	Artificial Intelligence
	Reverse Logistics	Machine learning
	Problem-Solving	Automation

Table 2- Systematic Review's Keywords

Through presented keywords was expected, and important, to retrieve data that is relevant to the domain of study, extracting recent scientific documents before 01.01.2018 and between 2018 and 2023, using only English words, were only articles and documents written in English were considered, to retrieve accurate information about the current utilization of AuI in Logistics.

The search string for this purpose was:

("Augmented Intelligence" OR "Artificial intelligence" OR "Automation") AND ("Logistics" OR "Reverse Logistics" OR "Supply Chain") AND ("Issues" or "Challenges" or "Techniques" or "Advantages").

Besides selected keywords, the terms that appear in the string were selected from the presented research questions from Table 1, to answer the presented objectives in the best possible way.

Table 3 presents the scientific sources used for this purpose:

Resource Database	Resource URL
Scopus	https://www.scopus.com/home.uri
Web of Science	https://www.webofknowledge.com/
Science Direct	https://www.sciencedirect.com/

Table 3- Systematic Review's Resource Databases

The next step consists in selecting the inclusion and exclusion criteria, both presented in Table 4:

Inclusion Criteria	Exclusion Criteria
Any scientific article showing evidence of AuI integration in Logistics	Articles published before 2018
Documents must be a journal paper or peered reviewed conference written in English	Articles that are not presented in English and duplicate
Only finished documents	Papers about Logistics but without focusing on the use of AuI techniques
Documents published between 2018 and 2024	Non-Academic papers (e.g., magazine reposts, newspapers)

Table 4- Systematic Review's for inclusion and exclusion criteria

After inserting the search string in sources websites, as output one has got all the identified articles through database search, which resulted in a total of (n=534) articles, i.e., we're in the identification phase of the PRISMA workflow. When moving to the screening phase, the first step is to remove duplicates. Here, (n=1) article has been removed, moving to the second step of the screening phase a total of (n=533) records. In this second step of the screening phase, the inclusion and exclusion criteria has been applied: articles older than 2018, articles not in English, and the other mentioned exclusion criteria were applied. This resulted in the exclusion of (n=515) articles, moving on to the eligibility phase a total of (n=18) articles. In the first step of the eligibility phase, articles abstracts were further analyzed and the ones that didn't have direct relevance to the study were excluded. Articles focused on other topics besides AuI and logistics, were considered very specific and non-relevant for this study, since the focus is for a wider applicability of AI in logistics, and not studying its applicability in a specific industry, therefore (n=5) articles have been removed. Thus, resulting in a total of (n=13) articles included in the qualitative phase, i.e., where one assesses the main text of the articles. In this phase one kept articles that have shown evidence of utilization of several methods of AI in several types of cybersecurity areas and addressed the topics of the research questions. The ones not contributing to answering the research questions have been excluded, resulting in a final list of articles included in the study of (n=13). This process is represented in the following workflow picture:

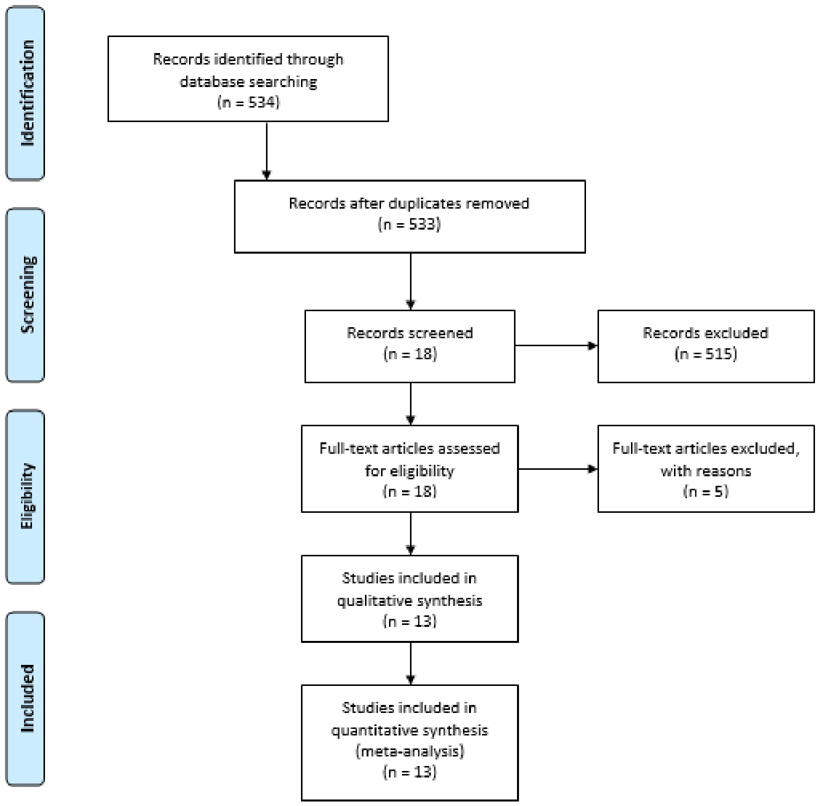

Figure 5- PRISMA Flowchart

The output of this research, i.e., the articles moved to the included phase resulted in 13 articles which are listed in the following table, along with a brief description of their contribution, conclusions, and gaps/future work suggestion:

#	Authors	Article	Contribution	Publication Type
[1]	(Adobor et al., 2023)	Integrating artificial intelligence into supply chain management: promise, challenges, and guidelines	Affirms that Logistics may face many improvements and face positive opportunities with AI adoption, but there are some oppositions from managerial and workers perspective.	Journal Article
[2]	('Aguezzoul & 'Pires, 2019)	Use of artificial intelligence in supply chain management practices and 3PL selection	Explains how the use of AI can help in the selection of the 3PL.	Journal Article
[3]	(Alomar, 2022)	Performance Optimization of Industrial Supply Chain Using Artificial Intelligence	Focus on the challenges that Logistics sector is facing and what are the major factors that contributes to it complexity and the needs to improve them. Also focus on the importance to preserve the environment and adopt environmentally friendly solution in the entire Supply chain, focusing on the advantages that are possible to achieve and overcome all the issues with the help of AI.	Journal Article
[4]	(Cannas et al., 2024)	Artificial intelligence in supply chain and operations management: a multiple case study research	Important research explaining AI applications on the field of logistics, que main barriers and problems regarding AI implementation and cases where AI is already applied in the field.	Journal Article
[5]	(Fosso Wamba et al., 2022)	Industry experiences of artificial intelligence (AI): benefits and challenges in operations and supply chain management	The authors explain the benefits of applying the AI techniques in the logistics and the challenges it may bring and that need to overcome.	Journal Article
[6]	(Javaid et al., 2022)	Artificial Intelligence Applications for Industry 4.0: A Literature-Based Study	Explains the role of AI in the Industry 4.0	Journal Article
[7]	(Kassa et al., 2023)	Artificial intelligence techniques for enhancing supply chain resilience: A systematic literature review, holistic framework, and future research	Provide insights of how the Supply Chain resilience should be enhanced with the use of AI due to the number of challenges and complexities in its growing demand and expectations.	Journal Article
[8]	(Lebhar et al., 2023)	Artificial Intelligence Applications in the Global Supply Chain: Benefits and Challenges	Focuses on the AI application in the Supply Chain to increase the efficiency in the decision making from the management perspective to stay ahead of the high competition presented in this field.	Book Section
[9]	(Niranjan et al., 2021)	Role of Artificial Intelligence in Logistics and Supply Chain	Explains how positively AI enhances all the departments and processes related to Logistics.	Conference Proceedings
[10]	(A. Shatat & Shatat, 2022)	The Use of Artificial Intelligence Capabilities in Logistics and Supply Chain Management: Major Challenges and Key Benefits	Briefly explains the major challenges of AI adoption on Logistics sector, about how it can help to overcome the issues and concerns the logistics sector is facing and what to expect.	Conference Proceedings
[11]	(A. S. Shatat & Shatat, 2024)	Artificial Intelligence Competencies in Logistics Management: An Empirical Insight from Bahrain	Explains what the challenges, positive aspects, and current AI perspectives in solving Logistics complexities.	Journal Article

#	Authors	Article	Contribution	Publication Type
[12]	(Shrivastav, 2022)	Barriers Related to AI Implementation in Supply Chain Management	This article explains briefly the AI lifecycle and their barriers in the logistics application.	Journal Article
[13]	(Singh et al., 2021)	Trends in Machine Learning to Solve Problems in Logistics	Exposes the ML techniques, which are supervised, unsupervised and reinforced learning, with their application in the major challenges in Logistics sector.	Journal Article

Table 5- PRISMA Results

2.3.2. **PRISMA Results Analysis**

By completing the research and following all the steps related to PRISMA methodology, now it's time to analyze the results from the previous search, through the reading of retrieved articles and respond to previously defined research questions.

SLRQ1 - What is the current state of AuI algorithms in Logistics?

Since the 4TH industrial Revolution, the flux of data has been huge, provided by multiple sources and technologies such as IoT, ML and AI. They play a significant role in the improvement and scalability of many businesses and Supply Chain Management (SCM) is one of them, where logistics are presented in almost every stage. These technologies are growing and improving very fast and how to use them properly and manage their interrelation, and most importantly their acceptance and development arise many barriers to their correct implementation. To increase productivity and, develop a proper management of available resources in order to be able manage and respond to inconsistent demand, any company need to develop a strategic coordination of all involved processes and associated activities to guarantee an efficient work and flux on reliable information between them to provide concrete and reliable outputs, and not only inside the company, but as well as between another businesses involved in the supply chain, to make it profitable and stay consistent to answer to the changing business environment and customer expectations. For this to happen, it is expected to start a shift of mindset especially from the board of directors, because SCM and logistics cannot be seen decades ago and need to be seen as a collaborative and connected environment, with intelligent and fast solutions to properly deal with uncertainties and costumer expectations [12].

AI is still a recent concept in logistics, and it is not adopted as it should be, to bring many positive and influencing changes. Through the face of challenges and complexities the logistics sector face nowadays, in all associated and integrated sectors, the adoption of AI should facilitate and improve all the existing processes, create much better working conditions and symbiosis between AI and workers, new and improved abilities to respond to customers and meet their demands [3].

Also, logistics strongly rely on both digital and physical networks, and to properly respond to high volume traffic and meet the established deadlines, they need to be considered as one element and work towards this goal, making the change from reactive to proactive in their operations, personalizing the services, automate processes, and improve the demand forecasting [3].

SLRQ2 - What are the major constraints of AuI integration in the logistics chain?

Probably the main issues related to the field of the use of AuI in logistics and supply chain is the associated high-cost integration and the people acceptance of this technology, being those afraid to be replaced [1].

Companies need to develop an AI integration plan in a proper manner, to avoid workers resistance and make them understand, and most importantly, make them feel that the human-machine collaboration main goal is enhance human capabilities and decision capacities instead of replacing them.[1].

[3] mention that it is very important to focus on human-machine interaction, by adopting and integrating these techniques, making them understand the improvements on capabilities and increases on efficiency levels of the processes across all logistics stages.

Upon search, these may be seen as the major issues and barriers of the use of AI in supply chain. The managerial department and work label as to be able to understand and identify what kind of AI technology exists, or, if not, and how their features and capabilities can improve certain fields in question by being properly implemented. The lack of definition of what are the purpose and goals to reach, not being properly informed about how AI works and what kind of AI technologies are needed for that purpose, and specialized professionals and continuous learning are also problems to overcome [4].

Reliable, high-quality data and proper technology infrastructure to build a consistent stream of information is another constraint that creates difficulties for this purpose. Even if there are already integrated AI technologies in certain companies, logistics is a very interlinked sector between many companies and entities, being so highly dependent on cross functional collaboration, so the need to create a collaborative and transparent environment is essential not only to ensure the high-quality information, but also to the fast-changing costumer behavior. The lack of professionals in the AI field, continuous training and development upon acceptance, cloud budget and other associated costs are another constrains in this field [12].

SLRQ3 - How can the challenges for logistics be solved by the implementation of AuI?

Logistics face many challenges and difficulties to stay resilient and respond to constantly increasing demand all over the supply chain [7].

AI should be considered a major and decisive technology to be applied in the Logistics to attain high levels of productivity, responsiveness and profitability and stay ahead of the competition, which is extremely high [8] , and gives the opportunity to reduce costs in the entire sector such as warehousing, inventory levels, packaging and transportation, production and purchase planning, enhancing customer service, demand forecasting and financial portfolios [9].

The high level of consumption and the high level of production and manufacturing worldwide also increase the concern with the environment, pointing out that more eco-friendly actions and sustainable development must be taken and implemented in the logistics sector practices through AI [3].

Many businesses may overcome their difficulties regarding the 3 Party Logistics (3PL) selection, for inventory management, warehousing, and order fulfillment with AI application [2]. The selection of the supplier is a very important stage for any logistics company, especially when it comes to quality, cost and time of product or service delivery through specific techniques application such as artificial neural network (ANN), multi-criteria decision model (MCDM) and fuzzy set theory [4].

Logistics and supply chain have been growing their operations and complexity during the past decades. The constantly growing demand and buying capabilities from customers require fast, efficient, effective answers in terms of product and service quality, as well as being in front of the constantly growing competition, plus maintaining service quality and increasing their revenues and profitability [3].

Through the already implemented IS and different networks between many departments and entities associated with logistics and supply chain, the flux of data is huge, but their management, association and interpretation is highly complex, and it is where the AI implementation may have an enormous influence on the entire logistics sector, providing real time and reliable information [3].

As mentioned before, with AI implementation on intra and inter organizational levels, it is possible to overcome the existent challenges by creating a transparent, coordinated, and collaborative environment, towards shared goals and rewards, mutual understanding of risks, opportunities, and goals, and from where it starts, strategic coordination of activities, functions, and dependencies [12].

SLRQ4 – Which AuI techniques are currently useful in this area?

Industry 4.0, which stands for the Fourth Industry Revolution, consists in the set of technologies as IoT, AI, robotics and automation, Big Data and the core feature, which is AI, enabling the creation of intelligent factories and smart manufacturing, what enhance the entire supply chain processes by providing real time and trustworthy information, through a unified database, influencing positively the entire logistic chain [6].

AI already started to be implemented in important Logistics activities such smart warehousing, operations planning and supplier selection, and companies which implemented these features saw significant improvements in their results.

Accurate inventory tracking and automated replenishment is also another AI implementation in logistics and distribution, and this leads to the cost minimization and efficiency in warehouse operations [12].

Recent research has shown that, in the sector of Logistics industry and warehousing, AI specific techniques were applied for efficient warehousing stocking and demand prediction, which are linear regression, random forest XGBoost, NLP was used for answer to customer generic enquiries and automate direct sales and another generic applications in stocking, shipping, picking and logistics optimization, resulted in effective communication with costumers, increasing their satisfaction and sales, reduction in transportation times and costs [4].

Another example in Logistics field that faced AI implementation techniques was reverse logistics, utilizing fuzzy logic and decision support system in Circular Economy and Machine learning for complex route problems resolution, evaluating potential 3PL and forecasting the return quantities. Jointly with collection activities and warehousing optimization, these implementations resulted in reduction of locations, inventory carrying and holding costs and increased environmental sustainability [4].

However, there is still a presence of many resistances in adopting and properly developing AI in this sector, as well as specific barriers that make it difficult to accept, integrate and expand the correct development of AI in logistics [12].

SLRQ5 - What are the advantages and disadvantages in applying AuI techniques in this field?

There are numerous advantages regarding the application of AuI techniques in this field, and to not focus on disadvantages, it´s better to express it as the challenges to overcome [5].

As mentioned before, AI is seen as a strong solution to high level of today's world uncertainties and unpredictable disruption, understand costumers' behavior to respond to the demand and to their expectations, properly define KPI's to stay ahead of the competition and stay in line with the progress during this fast-evolving technological environment [11].

It can be widely applied in many Logistics processes, being the heart of their interrelation and unify the entire chain, as well as used for specific purposes such as risk management, asset allocation, sustainability and many more. Being so, it is possible to make much better and reliable decisions, increase the productivity levels and profitability [10].

Reverse Logistics is one of the principal challenges involved in Logistics sector, which was identified as the one with more difficulties to be solved through the application of ML techniques [13], what gives us strength to verify and apply AI techniques to overcome this challenge.

AI is a relatively new, complex, and powerful tool bringing many changes to the entire industry and all involved parts, and everything that is new, complex and brings many challenges and complications doesn't normally bring fast and unanimous acceptance from people [12], but everything that seems to be a disadvantage, may also be seen as an advantage.

AI implementation in the logistics sector also brings some complex and not easy to solve situations. Many barriers can be find for successful AI integration in this field, namely lack of technology to capture, analyze and process data, lack of trust and acceptance, lack of clarity in defining objectives, unrealistic expectations , but most importantly for SCM and evolution, is the lack of reliable and quality data, and the lack of infrastructure to create scalable data, due to the high level of dependency on cross functional collaboration which is scarce, and for the successful implementation of AI in SCM the level on collaboration and connection between all interlinked chains and sectors need to be very high [12].

3. METHODOLOGY

3.1. Design Science Research

The objective of this research is to design a framework for proper and correct integration and use of AuI in logistics field, and after some research was decided to use design science research (DSR) methodology to achieve this goal.

DSR is a research methodology and problem-solving paradigm that focuses on creating and evaluating innovative IT artifacts or a final solution designed for a specific problem, to solve complex real-problems and contributing to already existing scientific knowledge, applied in fields such as information systems, computer science, and engineering (’Vom Brocke et al., 2020)

There are many literatures regarding DSR models, and our study we will use the one presented by (Peffers et al., 2007), consisting in a sequence of steps starting with problem identification and motivation, then defining the objectives to provide a solution for the defined problem, artifact design and development, following by demonstration and evaluation of the result and ending with the communication of the obtained result.

To understand the proposed methodology in this research, it's essential to explain its application and the expected outcomes, consisting in explain “what steps should an organization follow to successfully implement AuI in logistic processes?”. Figure 6 illustrates the described DSR model adoption.

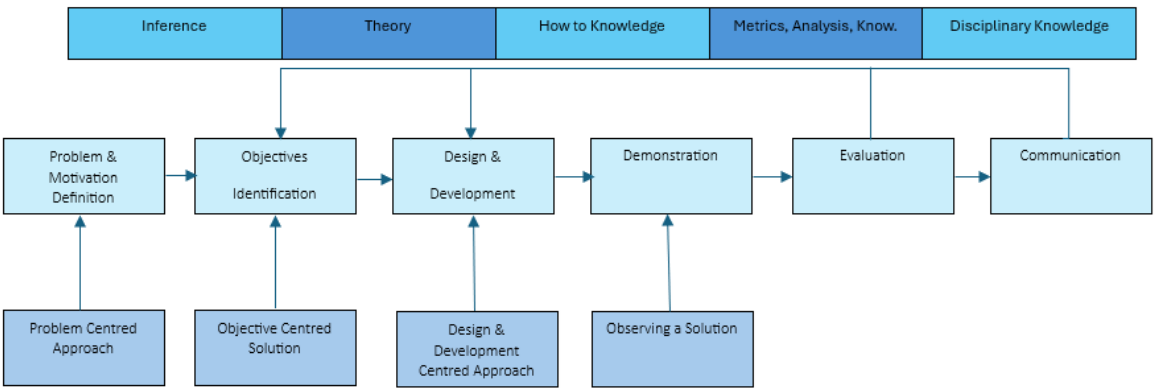

Figure 6- DSR Model Process Adaption (Peffers et al., 2007).

The DSR model consists in six phases and can be described as follows:

1. **Problem Identification & Motivation:**

   This first step consists in identifying the problems derived from real world situations and needs within a specific domain. The problem may be seen as a research gap to overcome and the value it will deliver by achieving the desired solution, where the results relevance explains the motivation behind reason why this problem should be solved.

2. **Objectives Identification:**

   It's important to define the objectives, whether qualitative or quantitative, as they form the basis of the solution. This requires understanding the current problems, solutions, and their effectiveness.

3. **Design & Development:**

   Is this stage, the researchers design and develop artifact to address the identified problem and to achieve the defined objectives. It's created architecture based on existing knowledge and new developed insights, leading to the creation of the artifact itself.

4. **Demonstration:**

   Once the artifact is built, it is presented as a desired solution that should be tested in the appropriate environment and context it was built for, to solve the defined problem.

5. **Evaluation:**

   Once the artifact is developed, it's measured and evaluated by obtaining feedback from experts in the related field or through examination of the demonstration phase, to ensure it meets the requirements and how effectively the provided solution supports the resolution of specific problems. In this phase, the artifact may be redesigned for adjustments and improvements, in accordance with the feedback obtained, to obtain more reliable and efficient artifact than the first one.

6. **Communication:**

   The 6th and final step consist in the presentation of the newly created artifact and the obtained results to the researchers, experts in the related field and the industry it may be applied, for the identified problem and in accordance to defined objectives to attain, providing the solution for real world context where the artifact can be applied.

With the application of all 6 phases presented and described before, it is intended to create an artifact, through the DSR model, that will improve the efficiency and effectiveness of the logistics sector by the application of AuI. In the next section, the application of the DSR model in this case will be explained.

3.2. Research Strategy

The research strategy, as mentioned before, consists in the application of the steps mentioned in the previous section, to properly conduct and apply the DSR process in this study.

It starts with the 1.) problem identification, once the study topic is identified, followed by the 2.) objectives definition to achieve the desired solution for identified problem, 3.) design and development of the artifact to be applied, 4.) the evaluation of the designed artifact to approve it application and 5.) the communication of acquired results and the contribution to the study field ('Vom Brocke et al., 2020).

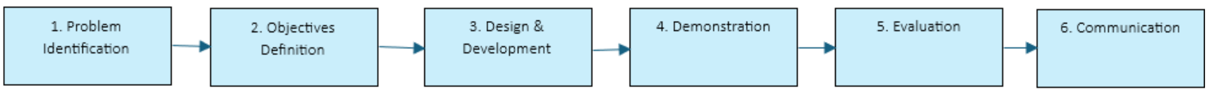

Figure 7- Research Process Elaboration

1. **Problem Identification and Motivation:**

   In the section 1.1 are presented the main problems and the motivation of this research, where logistics problematic and difficulties are identified, due to high complexities, interrelation and interdependence between processes and departments, and AuI integration as a major promising and innovative tool. Through literature review was intended to collect existing information on the topic to support the study and enhance the knowledge gained in this chapter.

2. **Objective(s):**

   It is intended to understand, through already described objectives in section 1.2, what is needed to achieve to overcome the presented problem. The objectives definition and understanding are important to use them as an input for process creation, and so, cover the identified gaps.

3. **Design and Development:**

This is the stage where the method is created. Through the complex literature review regarding logistics and AuI, it's important to understand the expected solutions to achieve, to build and efficient and effective method for proper integration of AuI in logistic processes. The literature review will provide a summarized context of the scientific area of the topic, jointly with the scientific research done on PRISMA.

4. **Demonstration:**

On the demonstration phase is intended to apply the designed and developed model in a practical way and demonstrate that it fits its purpose.

5. **Evaluation:**

The artifact will be brought to the attention of experts in the field of Logistics and IT fields once the design, development and demonstration phases are reached for proper evaluation. This is done to understand if the research output achieved the defined objectives or it was to be improved, as well as to understand how good the developed tool in terms of its applicability and efficiency is (Cleven et al., 2009).

6. **Communication:**

In this final phase the results will be shared and presented to the academic community for further discussion and evaluation, through the obtained feedback carried out during interviews.

4. PROPOSED METHODOLOGY

This chapter focuses on describing the development process for a methodology to implement and improve Logistics. The first section consists of the assumptions, on which the presented model will be based on, derived from the previous literature review and PRISMA methodology. The second section will describe in detail the design of the proposed framework and each step associated with it. In the 3rd section, a use case will be provided, describing the results that are expected to be attained. The research will not enter in the details of process implementation, since this step requires an investigation of each company´s requirements and would be out of scope of this research. Evaluation of the model will be the final step, where professionals of Logistics, IT and AI will evaluate the methodology and its applicability. The last section will present the discussion of the model considering the feedback from use case and interviews.

4.1. ASSUMPTIONS

The assumptions presented must be considered for adequate methods of elaboration and design, for proper assessment and the use of AuI in Logistics. The elaboration is as follows:

1. Logistics processes consist in ensuring the efficient flow of goods, information and resources, from suppliers to customers (Muthutantrige et al., 2023b).

2. Logistics key processes are Provide Logistics Governance, Plan and Manage Inbound Material Flow, operate warehousing and Outbound Transportation, according to APQC (APQC. 2024, 2024).

3. To improve Logistics overall performance, all four processes must be taken in consideration (APQC. 2024, 2024).

4. The activities that happen on key processes are from one of the most complete and recognized frameworks, PCF from APQC (APQC. 2024, 2024).

5. Assure that logistics systems can effectively integrate augmented intelligence technologies (Cano et al., 2021).

6. System quality and efficiency is measured by the data it contains, which means that humans are responsible for giving the right data at the right time to developed model for it to continue to learn as things change (Hurwitz et al., 2019).

7. System performance is essentially evaluated by the data quality it contains (Hurwitz et al., 2019).

8. For AuI, humans work in collaboration with machines, where machines enhance human decision-making by providing relevant data (Dellermann et al., 2019).

9. Humans are the ones responsible for results evaluation from automated tasks, decision making in non-routine situations and assessing when the data must be changed due to changing business needs and demands (Hurwitz et al., 2019).

10. Humans must evaluate the results of automated tasks and constantly feed machines with updated data due to business needs and demands (Zheng et al., 2017).

11. Cognitive technologies of AuI include ML, NLP, RPA and computer vision (Hurwitz et al., 2019).

12. AuI can be integrated within existing business systems and workflows, enhancing current processes without requiring complete overhaul (Hurwitz et al., 2019).

13. The steps needed to implement, and effectively attain augmented intelligence (Sadiku et al., 2021), (Hurwitz et al., 2019):

    • Decide whether to change the business process and task flow for human machine cooperation to drive better outcomes.

    • Select which tasks and decisions within the business process to automate.

    • Cultivate and look for the right talent, i.e. bilinguals with domain and technology expertise.

    • Have proper governance over automation and people.

    • Think through change management, specifically ensuring a smooth adoption in the new ways of work and upskilling talent.

    • Determine the proper AI tools.

    • Determine what data to acquire to better understand and model the business and customers.

    • Build the data models.

    • Test the results for reliability and accuracy.

    • Make sure your technology and processes have continuous human input.

4.2. Process methodology

The main point is to understand and find the most adequate way to implement AuI in the Logistics sector. Through the presented methodology that companies can use before implementing AuI tools in their current systems and in process integration. The following conceptual model was proposed according to the assumptions described before, and regarding the literature review. As mentioned before, the research will not enter in the details of the implementation process.

The steps description of provided methodology are presented below:

- Step 1: Choose Logistic Process
- Step 2: Identify Related Activities
- Step 3: Verify APQC PCF Compatibility
- Step 4: Identify Existing Systems
- Step 5: Verify Data Quality and Accessibility
- Step 6: Choose IA Tools
- Step 7: Verify Human-Machine Collaboration
- Step 8: Verify Missing Resources

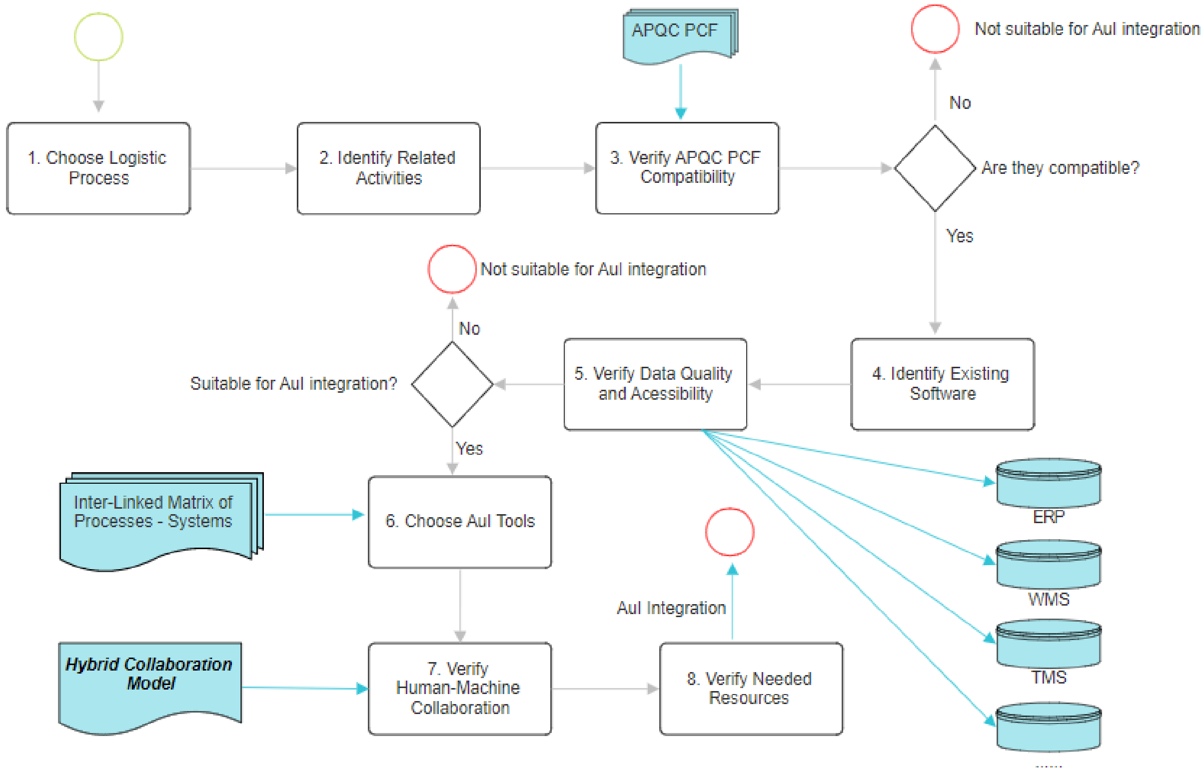

Figure 8- Proposed Framework to incorporate AuI in the Logistics

Step 1: Choose Logistic Process

The company must identify their current processes and choose the process (or processes) that is intendent to be improved according to what is intended to achieve. It is highly recommended to apply this to all the processes, because to achieve certain goals, the same AuI tool may be applied to different processes, enhancing more than one activity due to common technology in place.

Step 2: Identify Related Activities

The second step requires the identification of all related activities to the selected processes, making a clear map of all tasks involved that are currently applied on company operations, and the ones that are intended to improve the current state according to defined objectives.

Step 3: Verify APQC PCF Compatibility

The goal on this step, is the selection of the company business processes and activities that are compatible with APQC PCF processes, for suitable AuI integration. APQC PCF provides a list with the most important and standardized processes, in this case about logistics sector. Companies evaluate and compare, to this list, to understand what the correct and most appropriate structure processes should follow and which parts of the processes is missing in order to successfully attain the desired flux of work and efficient outcomes. The selection of APQC PCF activities is made according to the previously provided list from literature review.

Step 4: Identify Existing Systems

This step is one of the most important ones, as it provides the opportunity for smooth integration without major compatibility issues, ensuring that AuI can efficiently work with business operations. More, it is also expected the increase of interoperability between activities from different processes that share same systems, increasing transparency and efficiency as well, between processes. By saying so, it is expected the interdepartmental coordination, where different departments, such as procurement and warehousing systems jointly interact with AuI tools.

Step 5: Verify Data Quality and Accessibility

This is another very important step to take special attention. As mentioned before in the literature review, "Intelligent predictions depend on a rich store of relevant data." (Hurwitz et al., 2019). Due to the simple fact that AuI is meaningless without reliable data, where AuI requires high quality and large volume of comprehensive data, information systems provide the necessary infrastructure for its collection, analysis, storing and processing. Also, historical data that is already in place gives the possibility for accurate predictions and decisions and evaluate the current trends with past ones to provide most reliable information for decision-making. The verification of such data availability is made based on chosen system.

Step 6: Choose AuI Tools

Once the data quality and accessibility were verified, and they matched the criteria for AuI integration, a matrix is designed and illustrates how we identify the same systems used by different logistical activities, from activity Ax to Ay, belonging to different processes, thereby identifying the common AuI tool among them. The common color between activities means that the system that they use is common to different activities, and the same AuI tool can be applied.

Step 7: Verify Human-Machine Collaboration

Step 7 is where the main point of this research is verified, human-centric approach with machines playing assistive role. Once the AuI tools are chosen, before implementing them, we need to verify the human-machine hybrid collaboration, where machines mainly provide reliable and assertive information, and humans remain with the decision taking based on their expertise and business knowledge jointly with delivered inputs from machines.

Step 8: Verify Missing Resources

The final step consists in verifying what resources are already in place, and the ones that are missing to successful AuI integration in the logistics workflow. Once all previous steps are successfully achieved and analyzed, the importance of this step remains highly important to stay realistic about the company's actual capabilities of introducing such expensive and complex functionality. The availability of capital proper systems, technology and datasets, as well as qualified professionals with proper training and knowledge in the field, acceptance and adaptability of employees, the possibility of utilizing external resources and entities as 3PL, are some of the main components for successfully meeting the integration requirements.

4.3. USE CASE

The use case (demonstration) is purely hypothetical, since it always depends on the company's context, as well as their status and capabilities.

Let's assume that a certain logistic company faces complications in the transportation sector, with high costs associated with transport and maintenance, difficulties with delivery times and optimize route with proper scheduling. By using the presented method, the logistic company's goal is to overcome previously mentioned issues and optimize current processes, meeting the following objectives:

- Reducing transport and maintenance costs.
- Improving delivery times.
- Optimizing schedules and routes deliveries.

Step 1: Choose Logistic Process & Step 2: Identify Related Activities

The first two steps of the methodology follow the common logic of defining which processes and respective activities to select to solve the defined problems and achieve the intended objectives. These cases are purely hypothetical because companies processes and activities vary from company to company.

It was decided that the most suitable processes for defined problematic and settled objectives should be outbound transportation, which ensures that product reach the end users in an efficient, timely, and cost-effective manner, and internal governance, responsible for overseeing and manage logistics activities within an organization, where the associated activities should be properly selected to be aligned with the standardized and globally recognized processes of the APQC PCF.

Step 3: Verify APQC PCF Compatibility

By verifying with APQC Cross-Industry Process Classification Framework (PCF), the current company processes are compared to Operating Processes from section 4.0 – Manage Supply Chain for Physical Products, where logistics fit into point 4.4 – Logistics

Upon definition of four main processes and related activities, two main activities from each process (Provide Logistics Governance and Operate Outbound Transportation) were selected, in green boxes.

These activities were named and properly defined, from A1 to A4, by following manner

A1 – Optimize Transportation Schedules and Costs

Optimizing the schedule and costs of transportation services. This activity involves designing a logistics strategy by strategically creating delivery routes and systems, which optimize the overall transportation schedules and costs, and evaluating different transportation sources to select the most appropriate and cost-effective sources.

A2 – Define Key Performance Measures

Establishing measures for evaluating the performance of the logistics strategy of the organization. This activity encompasses establishing key performance indicators, including the logistics performance index, delivery in full, and delivery on time.

A3 – Plan, transport, and deliver outbound product

Organizing the transportation and delivery of outbound products, including planning and organizing the transportation, shipping, and delivery of the end products. This activity includes creating a plan that specifies dispatch and delivery of the product to its destination, as well the transportation.

A4 – Manage Transportation Fleet

Taking care of a range of functions related to the means of transport used for delivering end products. This activity includes managing vehicle financing, vehicle maintenance, vehicle telematics (tracking and diagnostics), driver management, speed management, fuel management, and health and safety management.

Manage logistics and warehousing (10219)			
Provide logistics governance (10338)	***Plan and manage inbound material flow (20936)***	***Operate warehousing (10353)***	***Operate outbound transportation (10341)***
Translate customer service requirements into logistics requirements (10343)	Plan inbound material receipts (10349)	Manage and track inventory deployment (10353)	Plan, transport, and deliver outbound product (10360)
Design logistics network (10344)	Manage inbound material flow (10350)	Receive, inspect, and store inbound deliveries (10354)	
Communicate outsourcing needs (10345)	Monitor inbound delivery performance (10351)	Track product availability (10355)	Track carrier delivery performance (10361)
Develop and maintain delivery service policy (10346)	Manage flow of returned products (10352)	Pick, pack, and ship product for delivery (10356)	
Optimize transportation schedules and costs (10347)	Control quality of returned parts (12708)	Track inventory accuracy (10357)	Manage transportation fleet (10362)
Define key performance measures (10348)	Salvage or repair returned products (20109)	Track third-party logistics storage and shipping performance (10358)	
Define reverse logistics strategy (16905)	Perform salvage activities (10366)	Manage physical finished goods inventory (10359)	Process and audit carrier invoices and documents (10363)
	Manage repair/refurbishment and return to customer/stock (14195)	Manage warehouse transfers (20957)	

Figure 9- Selection of Activities from APQC PCF Logistic Processes

Step 4: Identify Existing Systems

Upon activities have been defined, it’s time to understand what the technologies and information systems are already in place, and by doing so, understand which ones are the common ones between both processes, but with focus in those that relate to selected activities. From the figure 10 presented below, the selected technologies are ERP and WMS systems. Once the common technologies have been selected, a verifiability of data quality and access to it is the next step to take in order.

Technologies \ APQC Processes	Logistics Governance	Inbound Logistics	Warehouse Logistics	Outbound Logistics
Big Data Analytics	✓	✓	✓	✓
Augmented Reality			✓	
Blockchain Technology	✓	✓	✓	✓
Cloud Services	✓	✓	✓	✓
Drones				✓
EDI	✓	✓	✓	✓
ERP	✓	✓	✓	✓
WMS	✓		✓	✓
TMS	✓			✓
IoT		✓	✓	✓
RFID		✓	✓	✓
By Voice			✓	
Wearable Technologies			✓	✓
S&OP	✓			
CPFR	✓	✓	✓	✓
GPS				✓

Figure 10- Technologies selection from defined processes

Step 5: Verify Data Quality and Accessibility

Once the common technologies have been selected, a verifiability of data quality and the access to it, is the next step to take for proper selection and AuI tools integration. System quality and efficiency is measured by the data it contains, because the provided output will always depends on the data a certain system possesses. Intelligent predictions require a large amount of relevant data. Without high-quality data, the predictions will not be accurate. Once again, it depends on the company's context and capabilities. From TMS, compatibility ensures that the AuI can utilize historical shipment data, traffic patterns, and delivery schedules to suggest the most efficient routes, reducing delivery times and costs, while ERP ensures that the AuI can interact with different modules to enhance data analysis, and improve decision-making.

Step 6: Choose IA Tools

The elaboration of the matrix consists in establishing the common AuI tool upon technologies identification and selected processes and activities.

As mentioned before, the activities are mentioned in the Step 3, ranging from A1 – A4, respectively Optimize Transportation Schedules and Costs, Define Key Performance Measures, Plan, transport, and deliver outbound product and Manage Transportation Fleet.

The result has a common AuI tool for A1 and A3, which is Machine Learning and A2 and A4 for Data Analytics and Visualization.

			Logistic System Technologies					
			ERP	WMS	CRM	TMS	RFID	IoT
Logistic Processes (ex: APQC)	Provide Logistics Governance	A1				ML		
		A2	Data Analytics and Visualization					
	Operate Outbound Transport	A3				ML		
		A4	Data Analytics and Visualization					

Figure 11- AuI tools selection

Step 7: Verify Human-Machine Collaboration

The application of hybrid intelligence Human-Machine collaboration model consists in verifying once the tool is selected and identified, humans and machines work as a team through a collaborative manner and enhancing each other, through both unique characteristics. Once the task is elaborated, as well as its core elements, the four level layers of humans and machines are filled with the purpose of achieving mutual consent and understanding about each function and importance. For this example, only A1 and A3 tasks were taken, with ML implementation in TMS, just for approval manners.

Human	Task	Machine
1. Perceive vehicle conditions and delivery schedules. / Attention to urgent maintenance issues.	Optimize Transportation Schedules and Costs & Plan, transport, and deliver outbound product - ML in TMS	1. Collects data from GPS and sensors. / Real time info on vehicle status and location.
2. Remembers past incidents and mistakes to avoid repeating them in the present.	Managing different functions related to transportation used for delivering end products.	2. Processes raw related to vehicle condition and optimal route./Optimizes delivery routes using real-time traffic data.
3. Qualitative assessments, as evaluating the reliability of different vehicle brands and the effectiveness of maintenance providers./Decision like like scheduling maintenance, optimizing routes or assigning drivers, and strategies to enhance fleet efficiency and safety.	This activity includes managing vehicle financing vehicle maintenance, vehicle telematics (tracking and diagnostics), driver management, speed management, fuel management, and heath and safety management.	3. Identifies efficient use of resources, such as fuel-efficient routes and optimal driver schedule./ Automates routine decisions and provides decision support
4. Solutions for unexpected issues, like vehicle breakdowns. /Contingency plans and real-time adjustments, promoting smooth operations.	Humans apply business knowledge and experience, jointly with reliable insights and relevant data delivered by machines, enhancing human-machine collabora-tion, decision making and overall efficiency.	4. Executes automated actions such as sending maintenance alerts and routes updates.

Figure 12- Human-Machine Hybrid Collaboration Model Application

Step 8: Verify Missing Resources

The final step is to identify which resources are available and which are missing for successful AI integration in the logistics workflow. After analyzing the previous steps, it's crucial to assess the company's actual ability to introduce this complex and costly functionality. Key components for successful integration include available capital, proper systems, technology, datasets, trained professionals, employee acceptance and adaptability, and the potential use of external resources like 3PL.

4.4. EVALUATION AND RESULTS DISCUSSION

The evaluation of the proposed methodology for assessing the integration of augmented intelligence in logistics processes and its feasibility in the respective sector, with the aim of enhancing collaboration between humans and artificial intelligence, was conducted through interviews with experts in the fields of logistics and IT, by retrieving their thoughts views and insights.

The proposed methodology resulted from a set of assumptions obtained through a literature review, and the analysis resulting from PRISMA offered little to no contribution to its development. The purpose of these interviews was to determine the usefulness and validity of the methodology for the logistics sector, to increase the acceptability and integrity of augmented intelligence, and to obtain potential improvements that could be included.

Three interviews were conducted with experts to present, discuss and validate the proposed methodology. The interview took specialists from the logistics field, both logistics and IT field and purely from IT field.

The interview questions presented to the experts:

- *Do you consider the proposed methodology useful and why? If not, why?*
- *Do you have any critics towards the proposed methodology? Please explain.*
- *Would you consider implementing the proposed framework? Please clarify why/ why not.*
- *Do you have any recommendations or suggestions for further improvements for the proposed methodology?*

The questions allowed for understanding the usefulness of the methodology for the logistics area and the integration of augmented intelligence, assessing the experts' agreement with the presented structure, and subsequently gathering suggestions for changes or improvements that could be implemented in future work.

1. ***Do you consider the proposed methodology useful and why? If not, why?***

- ***Expert 1:*** *"* In terms of clarity, the objectives are well identified and aim to address a specific problem/objective. In terms of applicability, the methodology can be applied to concrete scenarios in the logistics chain. It is aligned with existing practices/theoretical models such as APQC PCF."
- ***Expert 2:*** *"In* my opinion, the methodology is consistent, presents value, and has potential to be further developed."
- ***Expert 3:*** *"The methodology is clear and easy to understand, it's innovative and for sure can be useful with some more insights."*

2. Do you have any critics towards the proposed methodology? Please explain.

- ***Expert 1:*** *"In terms of its flexibility, it may be necessary to provide more "empirical" evidence (real-world examples) to validate its usefulness/universality. A "rigid" framework is limited. Feedback and the iterative process: it would close the flow(s) with a "continuous improvement" mechanism to return to the beginning of the process and gather as much feedback as possible in each iteration.*
- ***Expert 2:*** *"For the presented methodology to be viable for any company, there must be a validation procedure for the process in which the company intends to integrate augmented intelligence. This is necessary to have a full understanding of the company's process, as each company is unique and operates differently from others. To integrate augmented intelligence, it must be adapted to the company's unique process, which requires validation to identify the critical and important points of the process in question. Since augmented intelligence aims to support human decision-making, it must have knowledge of the entire process to know where to specifically assist in achieving the company's objectives.*
- ***Expert 3:*** *"I would suggest, after the "Verify Needed Resources" process, a gateway to understand the if the cost-benefit is worth it, doing a risk analysis assessment, to make it clear regarding the realistic company approach. From a project manager approach, the implementation part plan of desired solution is very important."*

3. Would you consider implementing the proposed methodology? Please clarify why/ why not.

- ***Expert 1:****" Yes, but always with a Proof of Concept / MVP (Minimum Viable Product). Besides setting business strategic objectives and identifying business needs and constraints, should be conducted an analysis/benchmarking of industry trends. In the real world, everything starts with a business case:*

- *Analysis and Evaluation of Current Solutions (Gap Analysis)*
- *Strategic Alignment*
- *Functional Coverage*
- *Performance/SLA's*
- *TCO (Total Cost of Ownership)*
- *Alignment with Best Practices*
- *Analysis of Technological Foundations (vs Best Practices)*

- ***Expert 2:****" Yes, in my opinion any system that intends to enhance decision making, especially human, has many value in this industry field, because any inputs and help can from past experiences, history data, will improve significantly reduce the associated costs in this industry, and in transport and logistics the KPI on cost measures reduction is one of the most valued, and any feature that improve this will be very useful."*

- ***Expert 3:**" I believe so, because It's important to achieve new ways through which companies can reduce cost without firing employees, and this technology, more specifically Artificial Intelligence, has been adopted and implemented successfully and if properly implemented, as you suggest, can add many values. It will avoid many future corrections, costly and irreversible, being adopted as a preventive model and not a corrective one."*

4. ***Do you have any recommendations or suggestions for further improvements for the proposed methodology?***

- ***Expert 1:**" I would reinforce aspects related to the systematization of initiatives/projects for evolution, identification of priorities, constraints, and dependencies, estimation of investments, and associated operational costs. It's important to establish all the KPI's and metrics before proceeding with such expensive tool."*
- ***Expert 2:** "Once again, I would strongly recommend not only identify the process, but also its evaluation, for proper customization, having always in mind company's reality, and where is more appropriate to implement this validation in the proposed methodology."*
- ***Expert 3:** "I would recommend you do the validation and clear understanding about the used systems in the company in question and their interrelation, because you may have technologies that act "by themselves", without any connection with other source of information, and you may have the ones that are interconnect between them, such as TMS, ERP, or WMS. You have mentioned it, but in the methodology is not clear, because any company is a case, and you need to address that."*

The aim of this section is to review the feedback gathered from experts during interviews. The goal is to facilitate a final discussion on evaluating the previously developed methodology, focusing on assessing the reliability of integrating Augmented Intelligence in logistics processes. The analysis will consider aspects such as the value provided, feasibility of implementation, and potential areas for improvement.

On delivered value from presented methodology, all three experts agreed that the proposed methodology is valuable, that it focuses on specific domain, and it has potential due to its purpose and novelty, contributing to the field of logistics and the future of AuI.

Regarding the feasibility of implementing the proposed methodology, the experts emphasized some critical points, where feedback underscores the importance of flexibility and empirical validation through real-world examples, customization to fit uniqueness of company's processes, and thorough planning including cost-benefit and risk assessments to ensure successful implementation of the methodology.

Based on the feedback provided by the experts for potential areas of improvement in the proposed methodology, the experts offered valuable insights, highlighting the critical need for systematic project management, comprehensive evaluation tailored to individual company contexts, and thorough validation of existing systems, individual and overall, to ensure effective implementation of the methodology.

Finally, and to conclude, all three experts agreed they would consider implementing the proposed methodology, with proper insights and some extra improvements.

5. CONCLUSION

This chapter presents the main conclusions of the conducted research, discusses the limitations faced, and provides recommendations for future developments.

The purpose of the presented master's thesis was to develop a methodology for assessing the reliability of augmented intelligence integration in logistic processes and enhancing human-machine collaboration, which received positive feedback upon completion.

Valuable insights were obtained regarding the current state of the logistics field and augmented intelligence technology. Given its novelty and recent emergence, 'Augmented Intelligence', it was not easy to find extensive and relevant information on this topic. Nonetheless, a methodology was developed. The literature review allowed for the identification of a set of assumptions that led to the development of the proposed methodology to be adopted by the logistics sector, with the aim of assessing the feasibility of integrating augmented intelligence into logistics processes.

The present methodology aims to address human limitations in processing large amounts of information and making accurate decisions, replacing inherent assumptions and loss aversion with real-time facts and knowledge. It gives the possibility to evaluate the impact of this variant of Artificial Intelligence on the economy and contemporary business operations, which could be significant.

Numerous practical applications were demonstrated during the methodology presentation, detailing each step to clarify all phases and provide concrete examples of its application.

The evaluation of the methodology was conducted in collaboration with one logistics and two IT experts, to validate its usefulness for the logistics sector and the viability of AuI enhance human centric approach, as well as identify potential improvements to be adopted.

5.1. LIMITATIONS

Besides the mentioned attributes, the presented methodology also presents some limitations such as:

- Lack of knowledge and application cases due to its novelty. AuI is a recent topic and many times it was difficult to validate and find proper and concrete information.
- Even though AuI is a very powerful and impactful tool, it’s still very expensive to be widely adopted.
- To gain more reliable feedback, the interview should have included at least one AI expert. Nevertheless, this work serves as an initial step and can be expanded into a more comprehensive study.

5.2. Recommendations for future research

Regarding potential future work, some examples that it should be interesting to investigate:

- Cross-industry Insights from other industries that have successfully implemented AuI, adapting those best practices to the logistics sector. This exchange of ideas can enhance innovation and overcome sector-specific challenges.

- Conduct in-depth case studies across various logistics companies to gather empirical data on the effectiveness and challenges of AuI integration. This would provide a more robust understanding of real-world applications and outcomes and should enhance the provided methodology trustworthiness.

- Studies regarding ethical considerations and data privacy issues associated with AuI in logistics. Establish guidelines for responsible use, ensuring that data is managed securely and ethically.

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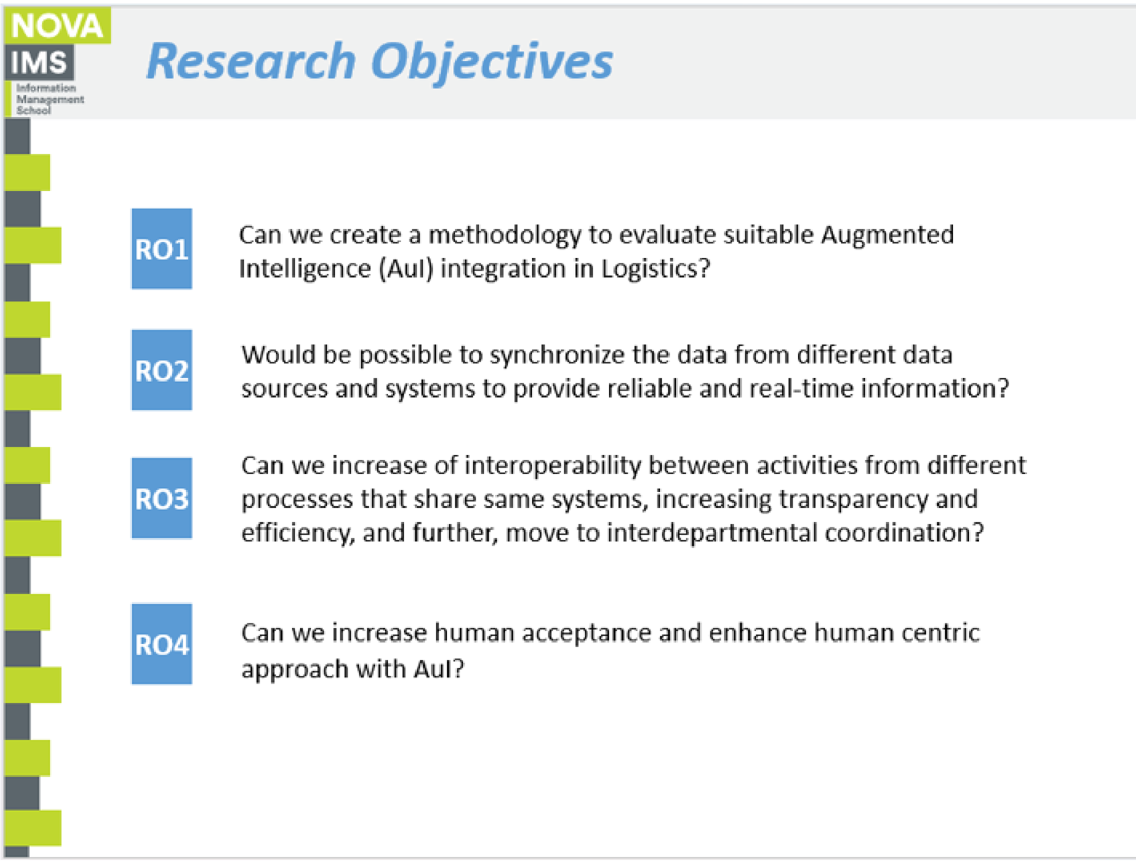
APPENDIX A – EXPERTS INTERVIEWS GUIDE



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Problem statement

1. Artificial Intelligence (AI) is gaining huge interest and relevance in many business fields, but its cost integration and workers acceptance is a big challenge to solve and overcome. Resistance when facing the initial implementation due to novel technology is the main point to overcome.
2. Logistics field is facing many challenges with constantly growing demand and supply chain complexities. The importance of logistics sector nowadays is very high, what makes the need for proper investments and improvements to increase service quality, overall process efficiency, cost reduction
3. High customer expectations, where customers expects faster delivery times, service quality with accurate order fulfillment and high service standards.
4. Sales losses and increased storage costs due to stockout, overstock, and inefficient warehouse management and operations, and concerns with transportation are examples of problems to solve and overcome.

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Proposed Framework

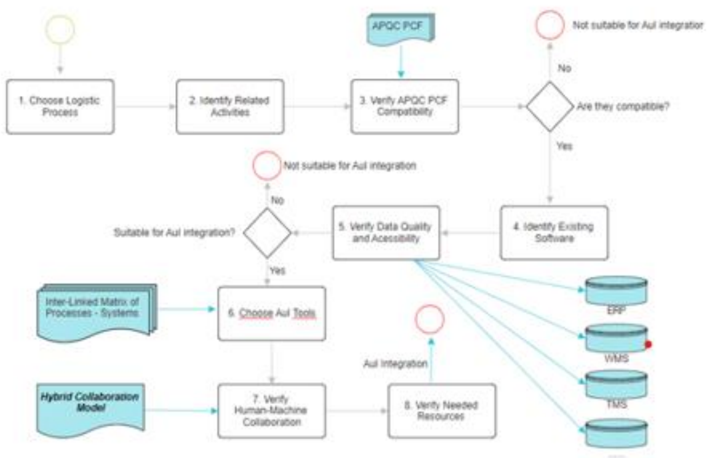

Figure 1. *Methodology to incorporate AuI in the Logistics*

Step 1: Choose Logistic Process & Step 2: Identify Related Activities

- Company must identify their current processes and choose the process (or processes) that is intendent to be improved according to what is intended to achieve.
- The second step requires the identification of all related activities to the selected processes, making a clear map of all involved tasks that are currently applied on company operations, and the ones that are intended to improve the current state according to defined objectives.

Step 3: Verify APQC PCF Compatibility

Manage logistics and warehousing (10219)			
Provide logistics governance (10338)	**Plan and manage inbound material flow (20936)**	**Operate warehousing (10353)**	**Operate outbound transportation (10341)**
Translate customer service requirements into logistics requirements (10343)	Plan inbound material receipts (10349)	Manage and track inventory deployment (10353)	Plan, transport, and deliver outbound product (10360)
Design logistics network (10344)	Manage inbound material flow (10350)	Receive, inspect, and store inbound deliveries (10354)	
Communicate outsourcing needs (10345)	Monitor inbound delivery performance (10351)	Track product availability (10355)	Track carrier delivery performance (10361)
Develop and maintain delivery service policy (10346)	Manage flow of returned products (10352)	Pick, pack, and ship product for delivery (10356)	
Optimize transportation schedules and costs (10347)	Control quality of returned parts (12708)	Track inventory accuracy (10357)	Manage transportation fleet (10362)
Define key performance measures (10348)	Salvage or repair returned products (20109)	Track third-party logistics storage and shipping performance (10358)	
Define reverse logistics strategy (16905)	Perform salvage activities (10366)	Manage physical finished goods inventory (10359)	Process and audit carrier invoices and documents (10363)
	Manage repair/refurbishment and return to customer/stock (14195)	Manage warehouse transfers (20957)	

***Figure 2** - Selection of Activities from APQC PCF Logistic Processes*

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Step 4: Identify Existing Systems

APQC Processes / Technologies	Logistics Governance	Inbound Logistics	Warehouse Logistics	Outbound Logistics
Big Data Analytics	✓	✓	✓	✓
Augmented Reality			✓	
Blockchain Technology	✓	✓	✓	✓
Cloud Services	✓	✓	✓	✓
Drones				✓
EDI	✓	✓	✓	✓
ERP	✓	✓	✓	✓
WMS	✓		✓	✓
TMS	✓			✓
IoT		✓	✓	✓
RFID		✓	✓	✓
By Voice			✓	
Wearable Technologies			✓	✓
S&OP	✓			
CPFR	✓	✓	✓	✓
GPS				✓

Figure 3 *- Common Selected Information Systems*

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Step 5: Verify Data Quality and Accessibility

- AuI requires high quality and large volume of comprehensive data, information systems provide the necessary infrastructure for its collection, analysis, storing and processing. Also, historical data that is already in place gives the possibility for accurate predictions and decisions and evaluate the current trends with past ones to provide most reliable information for decision-making. The verification of such data availability is made based on chosen system.

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Step 6: Choose IA Tools

			Logistic System Technologies					
			ERP	WMS	CRM	TMS	RFID	IoT
Logistic Processes (ex: APQC)	Provide Logistics Governance	A1				ML		
		A2	Data Analytics and Visualization					
	Operate Outbound Transport	A3				ML		
		A4	Data Analytics and Visualization					

Figure 4 *- IA tools integrated in logistics processes systems*

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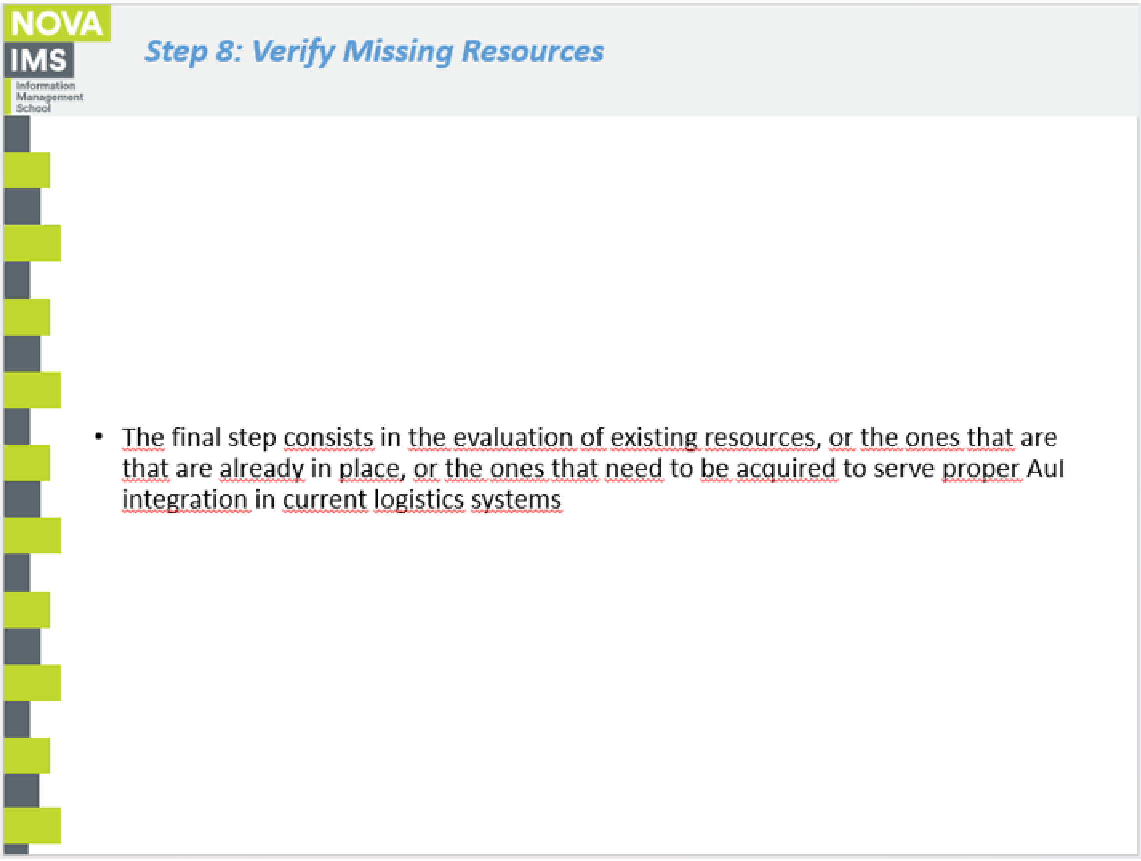
Step 7: Verify Human-Machine Collaboration

Human	Task	Machine
1. Perceive vehicle conditions and delivery schedules. / Attention to urgent maintenance issues.	*& Optimize Transportation Schedules and Costs - ML in TMS*	*1. Collects data from GPS and sensors. / Real time info on vehicle status and location.*
2. Remembers past incidents and mistakes to avoid repeating them in the present.	*Managing different functions related to transportation used for delivering end products.*	*2. Processes raw related to vehicle condition and optimal route./Optimizes delivery routes*
3. Qualitative assessments, as evaluating the reliability of different vehicle brands and the effectiveness of maintenance providers./Decision like like scheduling maintenance, optimizing routes or assigning drivers, and strategies to enhance fleet efficiency and safety.	*This activity includes managing vehicle financing vehicle maintenance, vehicle telematics (tracking and diagnostics), driver management, speed management, fuel management, and heath and safety management.*	*3. Identifies efficient use of resources, such as fuel-efficient routes and optimal driver schedule./ Automates routine decisions and provides decision support*
4. Solutions for unexpected issues, like vehicle breakdowns. /Contingency plans and real-time adjustments, promoting smooth operations.	*Humans apply business knowledge and experience, jointly with reliable insights and relevant data delivered by machines, enhancing human-machine collaboration, decision making and overall efficiency.*	*4. Executes automated actions such as sending maintenance alerts and routes updates.*

Figure 5 *- Human-Machine Hybrid Collaboration Model Application*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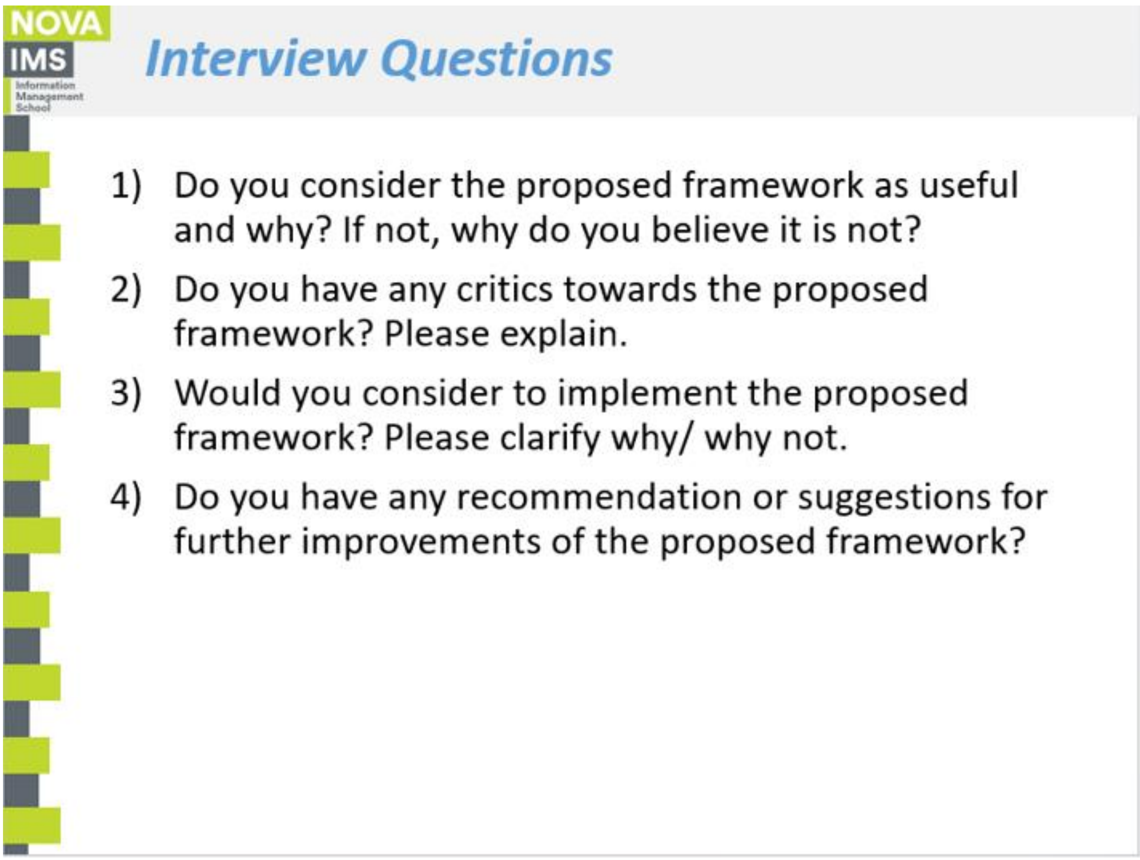
Step 8: Verify Missing Resources
• The final step consists in the evaluation of existing resources, or the ones that are that are already in place, or the ones that need to be acquired to serve proper AuI integration in current logistics systems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Interview Questions
1) Do you consider the proposed framework as useful and why? If not, why do you believe it is not?
2) Do you have any critics towards the proposed framework? Please explain.
3) Would you consider to implement the proposed framework? Please clarify why/ why not.
4) Do you have any recommendation or suggestions for further improvements of the proposed framework?


Thank you for your time and expertise!
Address: Campus de Campolide, 1070-312 Lisboa, Portugal
Phone: +351 213 828 610
Fax: +351 213 828 611
Acreditações e Certificações
Instituto Superior de Estatística e Gestão da Informação
Universidade Nova de Lisboa