Universiteit Leiden

ICT in Business and the Public Sector

The Role of Intelligent Automation in Transforming Military Supply Chains: A Qualitative Study

Naam:	Max Akkers
Student-no:	s3732037
Date:	26-08-2024
1st supervisor:	Prof. dr. S. W. Pickl
2nd supervisor:	Dr. Amat Lefort

Master thesis

Leiden Institute of Advanced Computer Science (LIACS)
Leiden University
Niels Bohrweg 1
2333 CA Leiden
The Netherlands

Contents

List of Abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
AHP	Analytic Hierarchy Process
BDW	Big data warehousing
CPS	Cyber-physical systems
CRM	Customer relation management
CRSP	Customer service resource planning
DNN	Deep Neural Networks
IA	Intelligent automation
IoT	Internet of Things
KPI’s	Key Performance Indicators
M-SCCIM	Military Supply Chain Cyber Implications Model
ML	Machine Learning
MoD	Ministry of Defence
MSCM	Military Supply Chain Management
NLP	Natural Language Processing
OPC-UA	Open platform communications-unified architecture
QA	Quality assurance
RPA	Robotic Process Automation
RAS	Robotic and Autonomous Systems
SCM	Supply Chain Management
SME	Small and medium-sized Enterprises
SRM	Supplier relation management
WMS	Warehouse management systems

List of Figures

List of Tables

Abstract

This thesis explores the implementation of Intelligent Automation (IA) within military supply chain management (MSCM), focusing on identifying factors for successful implementation within military logistics. By utilising technologies such as Artificial Intelligence (AI) and Robotic Process Automation (RPA), IA offers potential benefits such as enhanced efficiency, improved accuracy and improved decision-making capabilities.

This study uses a qualitative descriptive framework, combining data from surveys and expert interviews with professionals from KPMG and the Dutch Ministry of Defence (MoD). This research addresses the primary question: "What are the key factors when implementing Intelligent Automation into military supply chain management?"

Key findings indicate that while IA can significantly improve MSCM operations, several critical factors must be addressed. These include ensuring robust data security measures, creating a positive attitude towards technological adoption among personnel, and maintaining transparency and fairness in IA systems. Additionally, the study highlights the importance of adaptability and resilience in MSCM, emphasising that the ability to respond effectively to unpredictable events is the militaries main focus. Despite the potential benefits, challenges such as resistance to change and the complexity of existing IT landscapes within military organisations pose significant hurdles.

This thesis concludes that successful IA implementation in MSCM requires a comprehensive approach that includes strong frameworks, continuous education and training for personnel, and a focus on building trust in IA technologies.

Future research is recommended to broaden the scope by including diverse perspectives from various military organisations and exploring specific IA technologies' impacts on different MSCM departments. This will further validate the findings and enhance the applicability of IA in improving military logistics and operational readiness.

1. Introduction

1.1 Research background

Automation in a fast-changing world like today has earned its rightful place, which has and is putting through a radical change in human work over the past centuries (Waschull et al., 2020). Initiated in the 19th century, the manufacturing sector changed significantly, more efficient processes and overall costs went down. Starting from this first wave of automation, the production lines were relieved from bottlenecks, and manufacturing productivity could rise exponentially. All while human labour was freed up to do tasks which require more cognitive function (Davenport & Kirby, 2016).
In the second half of the 20th century, automation blossomed into more complex, cognitive domains. This seemed to follow the earlier manufacturing revolution but focused this time more on the cognitive tasks of back-office and front-office operations. This change was, among others, the effect of the introduction of Robotic Process Automation (RPA).

This technology embraced the mechanisation of knowledge work that traditionally required human input (Boudreau et al., 2015). The growth in popularity of RPA in the corporate world transforms operational efficiency and streamlined complex business processes, fundamentally changing the way businesses operate. However, it is mainly applicable to high-volume rule-based tasks that reveal limits when confronted with complex, unstructured data and decision-making requiring more diverse, human judgement (Willcocks et al., 2017).

This realisation triggers the next step in evolution when it comes to automation: integrating RPA with Artificial Intelligence (AI). Combining these two technologies creates Intelligent Automation (IA), this new technology creates a new horizon of end-to-end process automation. AI is able to expand the borders of RPA, previously limited to purely rule-based and inflexible tasks. Through the powers of AI in the aspects of adjustability, learning, and reasoning, IA can be used to automate far more complex processes than its predecessor RPA. RPA synergizes with AI to open a path to automation, which can handle the complexity and variability driving toward a future when entire processes might be able to work on their own with minimal human intervention (Cebuc & Rus, 2023).

In the environment of military operations, where decisions are often based on complex, multifaceted information, the potential for IA could be significant. With the growing complexity of modern war, manually analysed models like the traditional ones typically used by the military have become less and less successful (Christonsson, 2015). IA provides a compelling solution with the promise that it can allow one to conduct real-time data analysis, predictive modelling and an autonomous decision support system. If used correctly this could completely revolutionise military strategy and operational efficiency.

To have the ability to execute these military operations, one needs to be well prepared. Like every big operation, a significant process to gather all the information and supplies supersedes the actual operation. Just as a well-oiled machine requires a steady flow of parts, a successful military operation relies on robust supply chain management (SCM).

Military supply chain management (MSCM) focuses on the gathering and delivery of resources to ensure forces have what they need. Streamlining these critical processes through automation with IA can significantly improve efficiency and responsiveness.

The evolution of automation, from the steam-powered engines of the 19th century to the current use of intelligent algorithms, perfectly reflects the desire to pursue efficiency and effectiveness. Keeping this in mind, the integration of IA in MSCM presents the potential of redrawing the map of how military organisations get ready for battle.

1.2 Research problem

This paper, therefore, seeks to provide insights into how IA capabilities provide for faster and more efficient decision-making in the deployment and allocation of resources in the military. Therefore first there needs to be an understanding of what the capabilities of RPA and AI are. Thereafter, understand what the main difference is between a commercial supply chain and a military supply chain. This could impact the efficiency to what extent IA could improve MSCM. Problem Statement: "What are the key factors when implementing Intelligent Automation into military supply chain management?

The related sub-questions are:

- *What are the characteristics of AI and RPA?*
- *What is the main difference between a commercial supply chain and a military supply chain?*
- *What are the ethical and security aspects of IA usage in a military context?*

This thesis aims to seek a better understanding of how IA can further improve a military supply chain. This research will have a design that adopts a qualitative descriptive framework as its approach to seeking answers based on textual and primary data.

1.3 Research scope

The scope of this thesis is driven by the rapidly growing interest in leveraging advanced technologies to enhance the efficiency and effectiveness of operations within the military sector. Recognising the transformative potential of RPA and AI in automating routine, manual tasks, this research seeks to explore the integration of these technologies in a broader, more complex military context. RPA, while proven to be a robust tool for automating high-volume, rule-based tasks, encounters significant limitations when faced with complex processes. This limitation necessitates human intervention for tasks RPA cannot fulfil, especially when the input data lacks a predictable, structured format.

Against this background, this thesis aims to investigate whether AI technology could be an enhancer and complement to RPA, in particular when being brought to bear on military use cases in which the high complexity of the missions and high levels of adaptability characterise them.

Therefore, this study explores the potential of AI technologies and its capabilities that could aid in overcoming RPA limitations and specifically get applied in military logistics. That is, this opportunity would also be linked to the AI potential to further automate complicated processes of decision-making, improve data analysis, and even offer adaptive solutions within dynamically operative environments. Future work can be done to delve into the technical intricacies of AI technologies and research which AI technologies could have a significant impact on certain departments of the military supply chain. This paper will hence focus on the identification and analysis of emerging challenges and considerations of AI and RPA integration to ensure a sensible and informed process for the adoption of these technologies within the military.

This study addresses the unique challenges and considerations specific to military organisations, such as data security, system integration complexity and the need for resilient operations. With some differences which will be addressed later in this thesis, a military supply chain operates in similar fields as a commercial supply chain. In Figure 1 an overview is displayed of the possible fields in a supply chain where IA could be implemented. Here the potential for IA implementations is shown. Within these possibilities lies the logistics side of SCM. This thesis focuses on the benefits and challenges that may arise when aiding military logistics with the implementation of IA.

The scope also includes an analysis of the ethical and security aspects of IA, highlighting the importance of transparency, fairness and accountability in the deployment of these technologies.

Through qualitative data collection methods, including surveys and expert interviews, the study gathers insights from professionals involved in MSCM and IA, providing a well-rounded perspective on the potential and challenges of IA implementation.

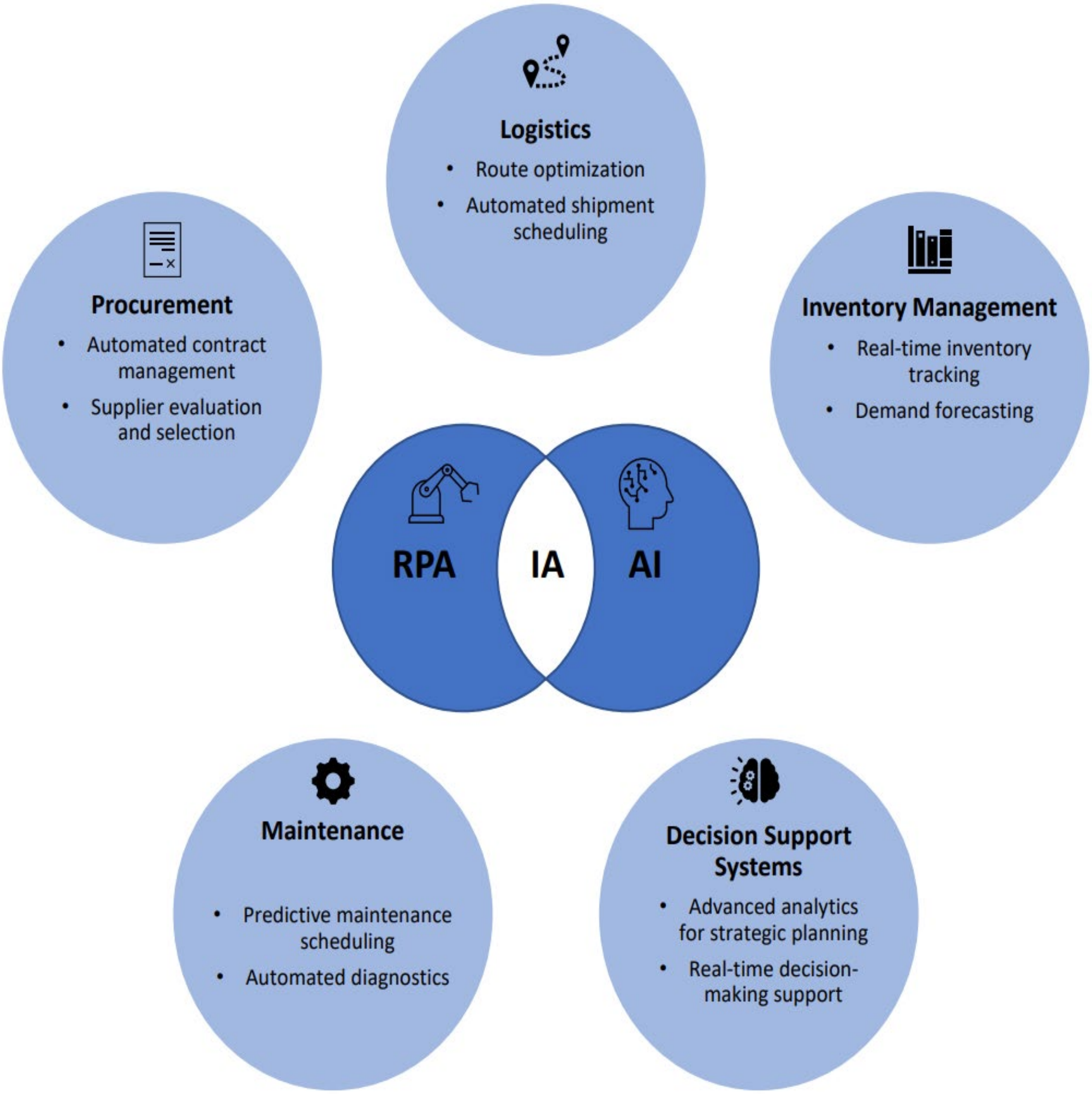


Figure 1 Potential IA implementations

2. Theoretical framework

2.1 Foundations and Evolution of Supply Chain Management

Supply chain management (SCM) has evolved as the most dominant modern business term, mostly referring to the effective management of the flow of goods, services, and even information from the point of origin to the point of consumption in order to meet the requirements set by customers. This includes an array of processes from procurement to production all targeting operating efficiency, cost rationalisation, and high customer service levels.

2.1.1 What is supply chain management?

The origins of SCM trace back to the 1980s, evolving from traditional logistics and operations management practises. Initially focused on the improvement of logistical efficiencies, SCM has grown to refer to the strategic coordination across the whole supply chain through the integration of the key business processes starting from the end users through the original suppliers (Lummus & Vokurka, 1999). SCM is the integration of planning and control of the flow of goods, information, and financial resources from suppliers of raw materials through factories and warehouses to the customer (Lummus & Vokurka, 1999). It emphasises the importance of creating an integrated relationship with suppliers and customers, making sure that the right quantity of products is delivered at the required place, right time, and right cost. A key aspect of SCM is that it helps build and maintain long-term relationships with all the entities taking part in the supply chain, which means suppliers, manufacturers, wholesalers, retailers, and customers (Lummus & Vokurka, 1999). This will contribute to effective communication, cooperation, and coordination of relations within the same supply chain. This will mean increased efficiency and customer satisfaction. A model of all information and material flow is shown in Figure 2.

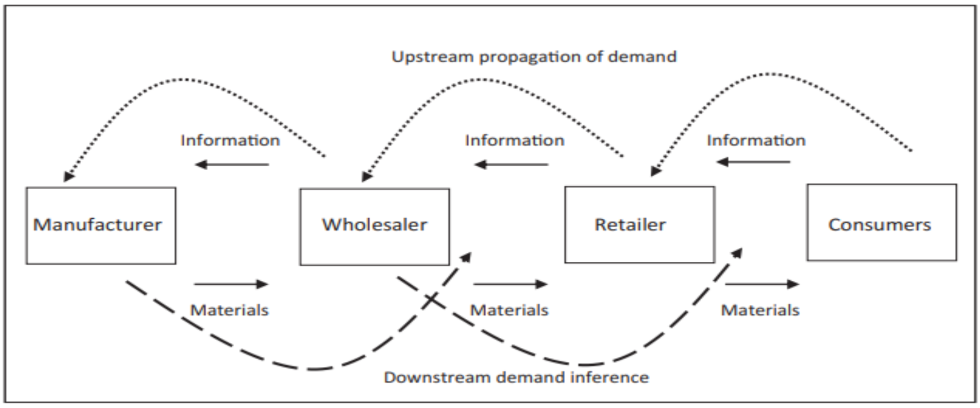


Figure 2 Supply Chain Structure Supply chain forecasting: Theory, practice, their gap and the future (Syntetos et al., 2016)

SCM involves several key processes, including procurement (sourcing and purchase of raw materials), production (changing raw materials into finished goods), and distribution (delivery of finished goods to the consumer).

Effective SCM would, therefore, include these processes across the supply chain, ensuring all the entities work as effectively as possible to meet customer demand (Gattorna, 2006). It is against this kind of background that globalisation and growing competitive markets have given birth to SCM as a strategic tool for firms aiming for competitiveness, thus improving their operational efficiencies and customer service. There is a strategic fit of supply chain activities to the business goals in realising the marketplace's competitive advantage (Tan et al., 2002). Technology has a great impact on SCM since it enhances the efficiency, transparency, and, most of all, the responsiveness of the supply chain to the general flow of activities. The state-of-the-art technological solutions incorporated into the supply chain have been integrated to guarantee very effective communication and collaboration amongst the stakeholders across the board. The following technological infusions help in improved accuracy for forecasting, optimising inventory levels, and finally streamlining order processing in support of the dynamic demands of today's market environments. These technology implementations gives an inside into how IA could be beneficial in a supply chain. A study done by Arenkov et al., (2019) indicates these are the most commonly used technologies in the recent development of SCM:

1. **Data Analytics and Visualisation Technologies:**
   These include the technologies that aid in organising business processes to the standards of SCOR and ISO. Examples of these digital technologies are Big Data, Artificial Intelligence, Cloud Computing and Storage, Quantum Computing, and Real-time Monitoring Platforms. These technologies are crucial for data analysis, supply chain planning, and enterprise activity administration.

2. **Technologies for Operations Automation and Equipment Management:**
   This area is focused on the automation of the search for suppliers, customer relations management (CRM), and customer service resource planning (CSRP). Equally relevant for automation are the relations between the supplier and the customer; Supplier Relation Management (SRM). These include automatic e-sourcing, robots, and warehouse management systems (WMS) in the classification of all technologies that are part of process management automation. Hereby examples are sensors and driverless vehicles among other Internet of Things (IoT) devices for the purpose of the general management of flow.

3. **Technologies providing communications between Supply Chain participants:**
   These include digital signatures, blockchain, social media marketing and platforms to provide communication and feedback loops between different elements of the supply chain. The technology would bridge different elements of the supply chain so that they are most efficiently interacting within a digital ecosystem. They are, however, the technology domains that underpin the digital transformation of supply chains and therefore mould more responsive, effective, or even sustainable supply chain ecosystems.

SCM has many challenges, considering a global environment that is quickly transforming with large and rapid changes in market requirements and trends in complexity, along with a greater focus on sustainability. Therefore there is a critical concern over supply chain risk management since disruptions may come from all sorts of different areas, including geopolitical tensions, natural disasters and supplier failures. This calls for robust management in terms of resilience and continuity strategies against risks (Dmytro et al., 2023).

The push for sustainability in SCM has also escalated (Zavala-Alcívar et al., 2020), driven by regulatory mandates and consumer demand for ethically and environmentally responsible practises. These are efforts to minimise their carbon footprint, ensure decent labour conditions, and reduce waste from shop floor to boardroom, all presenting challenges and opportunities for innovations in practice and technology (O'Rourke, 2014). This makes global supply chains very complicated. Increasing sustainability within the SCM has to be done while maintaining efficiency and competitiveness against changing regulatory landscapes, cultural differences, and technological development within countries. Where potential answers to these challenges come from the digital revolution in the supply chain also brings new challenges within the supply chain such as cybersecurity risks, data management, and most importantly, the enormous investments required in technology and skill development. To deal with these multidimensional challenges, companies need to take a futuristic and adaptive approach in SCM.

This would imply continued fine-tuning of their strategies towards digital innovation, sustainable practises, and the building of a strong, agile supply chain with the ability to respond dynamically to disruptions and shifts in the market. The collaboration and openness of suppliers and partners become material in handling risks effectively to guarantee sustainability. Thus, the adoption of digital technologies like IoT, AI, and blockchain, would provide the tools required to improve the level of visibility, decision-making, and efficiencies. This would, however, need to contribute to lifelong learning and development in order to secure adequate digital skills within the organisation. In other words, the SCM field represents a wide range of challenges that require resilience, innovation, and adaptability on the part of a firm. As such, the dedication to risk management, sustainability, and leveraging digital technologies, among others, should make it possible to turn problems into opportunities for growth and competitive advantage (Abbasi & Nilsson, 2012).

2.1.2 Foundations of supply chain management in military context

SCM within the military context is a comprehensive and complex approach, that seeks to ensure that every entity entrusted with the procurement, processing, and distribution of military resources is optimally coordinated and managed. This complex system comprises a network of organisations that include suppliers, manufacturers, service providers, and government institutions. All work as one organisation to ensure the safe and secure delivery of military material and services from point of origin through end-users that will support national defence and operational readiness (Christopher, 2023; Ekström et al., 2020).

Central to MSCM is its ability to manage and synchronise a wide array of activities and processes across diverse and often challenging environments. This includes strategic procurement of materials, the adoption of innovative technological advancements, the implementation of robust logistics and transportation strategies, and meticulous inventory and warehouse management.

Adaptability and resilience are two key factors for SCM in the military, ensuring that operations remain fluid and robust against a backdrop of unpredictability. Adaptability within this context means the supply chain's capacity to modify operations and tactics swiftly in response to shifting conditions without compromising mission objectives. This could involve the rapid reconfiguration of logistical routes to bypass emerging threats or operational shifts, scaling operations in response to increasing demands, and employing a modular approach to facilitate quick adjustments (Sani et al., 2022). In particular, modular systems make it much easier to substitute or integrate different components with each other, which is crucial when specific resources are scarce.

Resilience, on the other hand, is the ability to bounce back from the shocks delivered on the supply chain and keep the continuity of the operation running. This is most important in military contexts, where supply lines are often considered targets for disruption. Practises that could enhance resilience include those involving redundancy in the supply chain: more than one supplier for key items, or diversification of logistical paths to make sure that the failure of one component does not halt operations. Equally, investments and modernizations in infrastructure, including real-time monitoring for immediate visibility and response, were made in hardening the storage facilities and the communication networks for the needed robustness in the protection of supply chain assets from physical and cyber threats (Sani et al., 2022; Gürtlich & Lampl, 2022).

A well-prepared personnel force, educated with adaptive and resilient supply chain practises, ensures the efficient reaction of military personnel to the real environment. This will ensure a uniform and equal measure of the data received from the applications of the respective businesses. Develop strong partnerships with allies, private sector entities, and international organisations to foster increased adaptability and resilience. In such an alliance, the partners would share resources, best practises, and intelligence toward further strengthening the military supply chain. In essence, this kind of strategic flexibility and resilience within MSCM focuses on ensuring that logistic support is always effective, whereby high levels of operational effectiveness and strategic advantage are maintained even in the face of large-scale challenges (Gattorna, 2006).

Along with leading technologies, data analytics has the ultimate aim of improving decision-making capability, visibility across the supply chain, and performance optimization. These can include analyses of real-time data, predictive modelling, and the deployment of autonomous systems that are all meant to ensure more agile and informed strategic decisions (Gattorna, 2006). SCM is highly important in the military context, as one of the most dynamic domains that has taken a very holistic and strategic approach to operational excellence, including technological innovation, ethical practises, and commitment to security and sustainability. Therefore, efficiency and effectiveness remained the highest objectives to enhance the core roles of the military, support national defence objectives, and ensure the readiness and resilience of the military force (Webster, 1992).

2.1.3 Differentiating Logistics in Supply Chain Management

Logistics is a vital component of supply chain management, involving the planning, implementation, and control of the movement and storage of goods, services, and information. Certain key aspects of these logistics in a military supply chain are similar to those in a commercial supply chain. Both incorporate a Hierarchical Command Structure with clear lines of authority. To ensure the structure facilitates efficient decision-making and communication. Military operations and corporate endeavours alike require careful strategic planning, analysing potential risks or opportunities.

However, there are certain aspects in which these two logistics differ. The operational purpose of military logistics is to ensure that elements of military capability come together at the right place and time. One of two key differences is the interest of a military organization; this interest is not to maximise shareholder value but to advance the effectiveness and efficiency of the military organisation (Yoho et al., 2013). Military logistics operate at three different levels of activity: peace, mobilisation, and war (McGinnis, 1992). Logistics support for the country's military is often required to operate in a cost-efficient mode during peacetime, but often, on short notice, it must transition into an operation where effectiveness is paramount and cost is a secondary consideration (Kovács and Tatham, 2009).

Second, is the environment in which military logistics take place. These operations often take place in hostile environments where military logisticians are often faced with damaged physical and communications infrastructure, a lack of transport, and the threat of physical violence (Kovács and Tatham, 2009). These challenges demand a level of adaptability and resilience far beyond that typically required in commercial logistics.

Military logistics are faced with a significant amount of additional challenges. A key aspect to takeaway is an error in business logistics can lead to a loss in profit, in military logistics, it can result in death or injury (Yoho et al., 2013). Moreover, the stakes in military logistics are exceptionally high. Inadequate logistics support can jeopardize entire missions and put lives at risk. For example, during the Iraq War, insufficient logistical planning led to critical shortages of equipment and supplies for frontline troops, highlighting the severe consequences of logistical failures in a military context (Yoho et al., 2013). This underscores the necessity for robust, flexible, and responsive logistics systems that can operate effectively in the most challenging environments and under the most demanding conditions.

2.1.4 Security requirement of military supply chain management

Security in MSCM covers more than the area of protection of physical assets; it includes the protection of sensitive information, ensuring the integrity of the supply lines, and maintaining the operational readiness of the armed forces. In fact, the security-strategic importance of this supply chain cannot be overemphasised, considering the relevance that its vulnerabilities have directly toward national security and defence capability (Christopher, 2023). The military supply chain deals with classified materials and sensitive information that require stringent controls to prevent unauthorised access and espionage. Information security measures, including encrypted communication channels, secure data storage, and rigorous access controls, are essential to protect operational plans and supply chain logistics from potential enemies. There is a serious limitation to physical security in the bid to guard against theft, sabotage, and terrorism on military assets. It involves safe modes of transportation, packaging, and rigorous monitoring.

The key to this is resilience, and the military supply chain should be designed to defy and be able to recover promptly from attacks, natural calamities, and other disruptive instances. Redundancy in supply routes, diversification of suppliers, and contingency planning can help achieve this resilience (Sheffi & Rice, 2015). In most cases, military operations take place in a volatile environment, where the threat landscapes keep changing. It should, therefore, inherently be an elastic SCM security framework that is capable of agility response to even the most unforeseen forms of threats. This shall entail constant risk assessment, instant intelligence sharing in real-time, and agility in rerouting supplies and altering strategies. Integration with advanced technologies such as blockchain, RPA, AI, and IoT brings great transparency, efficiency, and automation advantages in the military SCM. However, it also involves the risk of cybersecurity. Protecting against cyber-attacks, securing IoT devices, and ensuring the integrity of blockchain transactions have become crucial aspects of SCM security in the military (Hiromoto et al., 2017). To comply with the level of security required by a military force, several requirements need to be met to ensure a safe network for a military SCM.

Continuous cyber threat intelligence

“In order to effectively protect a system, one needs information” (Griffioen, 2019). The more valuable the information is, the greater the possibility of having a competitive edge over your enemies. In cyber warfare, the upper hand is based on whoever has the latest intel. Knowing your enemy's moves is an absolute key while, at the same time, keeping your own tactics hidden. In cyber threat intelligence, timeliness is everything; information in the public domain has a very short shelf life. Defenders need to disseminate intelligence on activity fast enough to be ahead of the attacker’s action. MSCM systems constantly track and analyse cyber threats. That might be either a special cybersecurity team or some of the most advanced AI tools, which scan huge datasets for on-the-fly threat and flaw assessment. Having this continuous cyber threat intelligence increases the ability to have valuable information about the adversary’s operation as well as your own.

Blockchain security protocols

The use of blockchain technology produces transparency and security which makes it ideal for military supply chains, but its applications still need extra security to ward off advanced cyber threats. Blockchain technology gives surety to very sensitive military data through ideal decentralised control, strong encryption, and tamper-proof records. However, military cyber threats are complex, so a layered security approach is necessary. This includes advanced encryption to restrict access, secure hashing algorithms to prevent data alteration, and multi-signature transactions for extra verification before actions are taken. For example, Rahayu et al. (2021) introduced the blockchain for military logistics, supporting the view: that it improved transparency, data integrity, and secure communication with better fraud prevention, communication, and tracking, all of which are considered very important to be improved for military operations.

Security governance

RPA uses a series of robots to accomplish repetitive activities like order processing, which frees up time for employees and minimises errors. Many such automated systems are also prone to cyberattacks; the intention could be to either disrupt operations and mess up supplies or steal critical data. Studies on supply chain security, like the one by Voss and Williams (2013), emphasise the importance of good security practises. In RPA security, take the same approach: always strive to improve your skills and share information effectively. The RPA security governance framework, therefore, has to be sound enough to counter such cybersecurity challenges, and it would range from a wholesome system of access controls, strong identity management protocols, and periodic security audits. Access controls should ensure that only authorized personnel interact with the RPA systems to limit the untoward risks of unauthorised access. Identity management protocols include multifactor authentication and periodic user verifications, which are additional security methods applied in RPA systems to ensure that users are the real people owning the set access authorizations and not just any trials of access that may be unauthorised. The processes of military SCM based on RPA should ensure that their infrastructure is safe and resilient, with regular security audits, so that probable cases of vulnerability are identified and fixed. Research done by Sobb and Turnbull (2020) in "Assessment of Cyber Security Implications of New Technology Integrations into Military Supply Chains" focuses on the critical role that cybersecurity plays in keeping military supply chains safe from vulnerability to the disruptive consequences that cyber threats may impose. The deployment of new technology, such as RPA, within the supply chain may make this more effective; however, it represents a very high cybersecurity risk as this may result in system failures throughout and will cause disruption to military operations. The paper thus recommended the Military Supply Chain Cyber Implications Model (M-SCCIM), displayed in Figure 3, as a method by which military decision-makers may be able to enhance their understanding of security vulnerabilities related to certain aspects of new technology integrations and therefore need holistic security controls against those vulnerabilities.

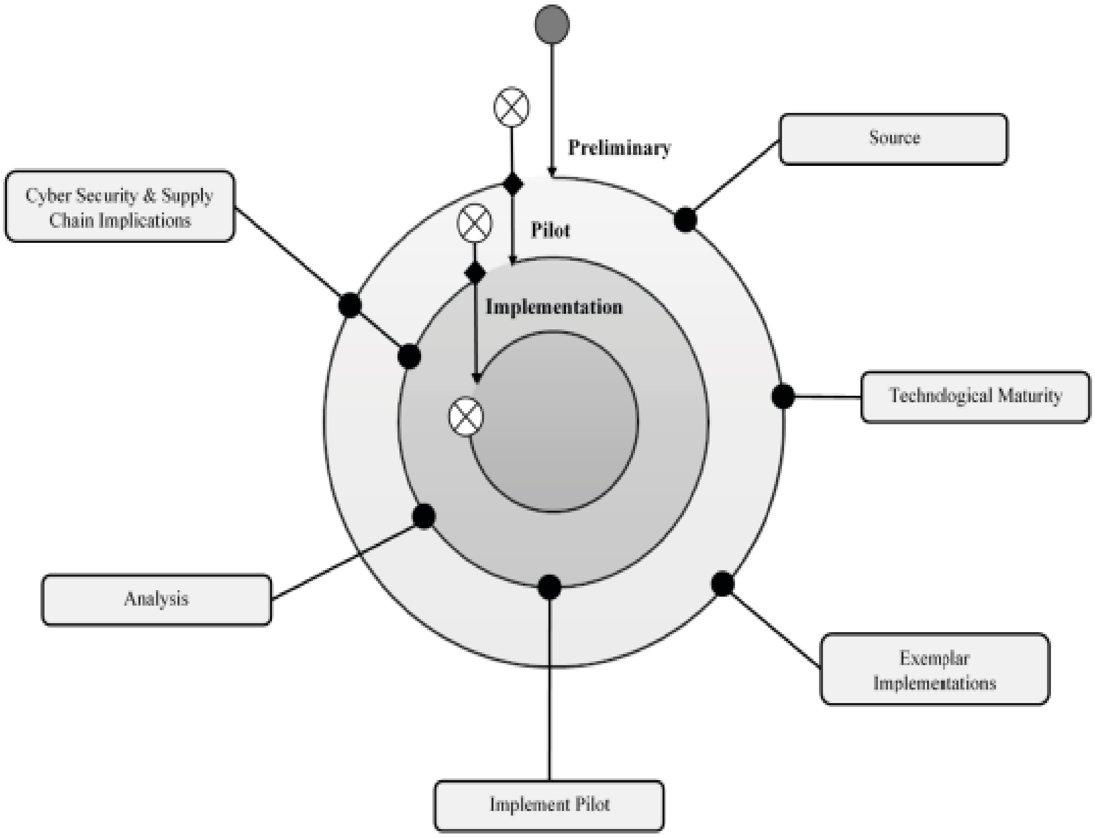


Figure 3 Military Supply Chain Cyber Implications Model (M-SCCIM) (Sobb and Turnbull, 2020)

This strategic framework was developed in order to identify and mitigate the dangers associated within the cyberspace of the military supply chain. The model emphasises that the cyber threat has to be paramount in order to ensure the military supply chains are not exposed to vulnerabilities most likely to result in disruptive consequences.

These technologies form part of the supply chain with RPA to be able to increase operational effectiveness. The model is constructed out of six individual steps:

1. *Identification of Vulnerabilities*
   The first step in the model is the systematic identification of all vulnerabilities that may be impacting the military supply chain due to the integration of new technologies in relation to cybersecurity. It includes an assessment of the risks from threats to software, hardware, and network interfaces supporting supply chain operations. In this first phase the section contains source, technological maturity, exemplar implementations, and cyber security and supply implications. These sections of the M-SCCIM are part of the preliminary step where the initial vulnerabilities will be researched.

2. *Analysis of Threats*
   Vulnerabilities require analysis of the threats that may occur. It deals with understanding the sources of threats. The threat source could be state actors, terrorists, or insider threats. Also analysing the impact of these sources and the probability of their occurrence. This step is important, since only at this stage can the company or organisation prioritise the risks according to their consequences and likelihood.

3. *Development of security controls*
   The model indicates that following this analysis, the development of tailored security controls needs to be implemented to mitigate these risks. This includes the design of both technical and procedural defences, engineered to protect against identified vulnerabilities and threats.

4. *Implementation of controls*
   In this step, the security controls are now deployed into the military supply chain systems. It may entail incorporation into the present systems of those protective measures, ensuring that the new integrated technologies are within the protective measures and that newly trained personnel are trained to adhere to increased security protocols. In this step the pilot phase has started, this phase informs whether the preliminary phase assessments were accurate.

5. *Continuous monitoring and improvement*
   With such continuous oversight, it would be feasible to detect even the slightest failure or breach possible at the earliest stage, which allows for immediate corrective actions. In addition, the model emphasises the aspect of ensuring that there are continued and improved updates in security controls, in line with the rate at which cyber threats are changing and technological growth is advancing. After this pilot phase the solution is ready to be implemented where this loop starts over again.

6. *Feedback loop*
   The feedback loop includes mechanisms for the continued process of refactoring and framework enrichment. This includes the collection of insights from the operation of the system, learning from any security incidents, and the evolution of security measures based on these new findings and emerging technologies.

AI and Machine Learning security

Predictive analytics and decision support for a military supply chain require very sophisticated AI technologies. However, these will imply that such systems require high scrutiny for them to maintain integrity and be effective. It does, in fact, need to ensure greater attention to the machine learning techniques that, at the same time, require a sort of continuous monitoring of the AI-driven systems for anomalies. Researched by Kaledio and Letho (2024) multiple continuous monitoring key aspects were deemed significant: data collection, data processing, model evaluation and an alerting system. More about these topics will be discussed in Section 2.3.

Security measures in AI and Machine Learning are currently not uncommon in Industry 4.0. What makes these security regulations that much more important in a military supply chain than the regulations in a commercial supply chain, is the type of information the system gathers. Military operations often involve sensitive and classified data, where breaches can have significant consequences for national security and operational readiness. In contrast, a commercial supply chain focuses primarily on optimising efficiency and reducing costs. These security concerns, while still very important (Mittal & Panchal, 2023), are typically less important compared to military applications.

The above precautions for certain threats would justify strong security measures that military organisations need to take to secure not only their machine learning practises but also the continuous monitoring of their AI-driven systems. This was to ensure the technology remains valid and reliable for purposes related to critical military affairs. Solid security in SCM military systems applying AI, whose intention is to identify and remove attempts that aim to put down the reliability of this system, should be mitigated in the face of such threats. This can be done through an anomaly detection algorithm that finds the use of an irregular pattern either in the data inputs or models, thus indicating potential tampering (Baryannis, 2018). This is not to take away from the fact that, based on the best practises in machine learning, it is fairly obvious that federated learning will reduce the risk of centralised data breaches (Bonawitz et al., 2021).

Supply chain redundancy and diversification

Building redundancy and diversification into the supply chain is of paramount importance toward better resilience against targeted attacks and disruptions so that, on a larger scale, operation continues even in cases of compromise in part of the supply chain. Redundancy in the supply chain means an extra creation that should work in various facilities as a buffer against different disruptions. These creations could be extra inventory, keeping one critical component from many suppliers, or having logistics options as a backup. On the other hand, diversification is based on the spread of risks, thus making use of a wide range of sources, routes, and methods of supply chain operations to reduce the level of dependence on any single element that can become a failure point. The use of combinations of these strategies and mixes in the supply chain secures probable disruptions and shapes a kind of flexibility for this supply chain in relation to those unforeseen challenges. The approach ensures that military operations will stay within a critically important level of resources and support for missions and operational effectiveness.

However, the implementation of such resilient strategies includes clarity of care on the one hand to help increase resilience but is associated with costs since redundancy and diversification will lead to an increase in operational expenses.
The main strategy for building resilience lies in flexibility and redundancy (Sheffi & Rice, 2015). This resilience is important in both a military supply chain and a commercial supply chain. Both value flexibility and redundancy, but a military supply chain places a higher emphasis on these aspects to ensure operational readiness and mission success. Whereas commercial supply chains aim to achieve a balance between flexibility, redundancy, and cost-efficiency to meet customer demands while maintaining competitive advantage.
Sheffi & Rice (2015) believe that resilience could be engineered through mechanisms of creating redundancy, such as keeping spare resources or increasing flexibility, and developing organic capabilities to sense and move against threats as fast as possible. In light of this study, there seems to be a strategic advantage from a resilient supply chain that enhances the organization's ability not only to survive or remain stable post-disturbance but also to gain a competitive advantage. Redundancy and diversification become principles to be followed in such situations as in a military supply chain to have a robust and responsive support system. Militarily sensitive SCM will have more resiliency to ensure that the force is well-equipped and ready for any challenging circumstances.

Incidents response and recovery plans

The incident response and recovery plans must be well structured to ensure that there is a quick response to breaches and reduce the impact such breaches are likely to have on the security situation. The plan should include prearranged response protocols, communication plans, and recovery strategies that would aid in the quick resumption of operations once an incident occurs. All these plans operate based on the coordination of a variety of stakeholders' responses and should be adapted to the peculiarities of each incident to resume activity with the least damage to the efficiency and security of the supply chain. Not only do these considerations point to high stakes in terms of operational efficiency, but through the national security of the populace, this makes the development and execution of such plans even more crucial. This represented the sort of specialised need that would set the incident response and recovery approach for the military as uniquely accommodative to the possibility of targeted attacks and urgent needs for a very forceful, swift response. Principles of managing uncertainty, balancing return rates with demand, and making material recovery more predictable are very helpful in devising very effective incident response and recovery plans in a military setup (Chowdhury & Quaddus, 2016). This may also include a lot in the improvement of predictability and reduction of uncertainty to create resilience and security in the military supply chains. So, a military supply chain ingrained with these principles would further ensure resilience in standing or recovering from the varied forms of disruptions, hence providing more assurance toward the robust and responsive infrastructure to support military operations.

Having mentioned the characteristics of supply chain management and the differences between a commercial supply chain and a military supply chain. In Chapter 2.2 the challenges and benefits of the implementation of RPA will be discussed. Here, RPA is an example of an automation tool that, with the right support from AI, can be transformed into IA. Diving into the benefits and challenges of RPA, a certain number of factors will be derived from this theoretical analysis. The most important factors will be adopted into the IA category in the conceptual framework since RPA is a technology in the overshadowing term IA.

2.2 The Role and Impact of Robotic Process Automation

In this chapter the general concept of RPA will be discussed. Focusing on the introduction into RPA, how and where it can be used and the potential benefits and risks this can cause when using this to optimize the military supply chain.

2.2.1 Definition and core principles of RPA

RPA is one of the largest new technologies in business process automation, streamlining repetitive and mundane tasks that have traditionally bogged down administrative sectors. The major motivation for the import of RPA technology in the digital workplace is to streamline digital operations and gain a competitive edge (Syed et al, 2020). This technological intervention would be specific to functions, which are classified under back offices and form an integral part of the core processes related to procuring HR and finance by organisations. These areas, which need operational support systems like ERP, CRM, and SCM for their functioning, are now under an extreme metamorphosis through the deployment of RPA for effective management and service delivery (Aquirre et al, 2017).

The traditional approaches to enhancing back-office processes have ranged from centralization and process optimization to technological enhancements with ERPs and CRMs and even outsourcing to achieve cost reductions (Chakroborty, 2017). However, behind its positives, it hides a set of negative aspects: including management costs and service level agreement complexity. Further, although technology in processes has a way of lessening work intensity, the fact is that an extremely high number of repetitive tasks require a human touch, which could bring along inefficiencies and possible errors in mass cases. Enter RPA: the software-based solution for automation of high-volume, repetitive tasks that a human previously performed and thus provides strategic optimization of business processes without massive system overhaul or deep integration with the existing IT infrastructure.

Built on the shoulders of traditional process improvement methodologies, RPA is an efficacious and trendsetting strategic enabler that lifts businesses to unimagined levels of operational efficiency and agility. The very nature of RPA allows its integration into the system and enables it to work with the system without any requirement for radical change to IT infrastructure (Syed et al., 2020). This feature of RPA makes it an attractive option for businesses looking to harness the benefits of automation without the complexities and costs associated with major system overhauls. RPA's core principles revolve around simplicity, scalability, and adaptability.

In essence, RPA robots replicate human interaction with digital systems, allowing a wide scope of tasks to be executed, from data entry and transaction processing to more complex analytics and decision support, all within the parameters of existing enterprise applications. This capability also infuses the power of AI with human attention to enhance accuracy and speed while freeing human resources for more strategic, creative, and customer-centric initiatives. The scalability of RPA offers businesses a way in which to start with small pilots that can later be adopted by bigger, mainstream businesses at the right pace (Kaya et al, 2019).

It becomes a foundational step on the path to more advanced types of automation, such as Intelligent Automation (IA), where the synergy between RPA and AI technologies like machine learning, natural language processing, and cognitive analytics opens new possibilities. Thus, it may be said that this integration finally leads to enterprise empowerment, beyond automation of all rule-based activities and further to those needing judgement, learning from unstructured data, and decision-making, thus expanding the scope and impact of the automation initiatives (Tyagi et al., 2021).

All in all, RPA represents a new paradigm in which businesses will have to think about process optimization and digital transformation. Its core tenets represent the future with digital workers and human employees in a unified and integrated stance that will bring forth more resilient, efficient, and even innovative business models. RPA will stand testimony to the power of technology that allows redefining new boundaries of operational excellence and competitive advantage as organisations take on this transformational journey.

2.2.2 Evolution of RPA technology

The course of RPA development coincides with the increase in demand and need for effectiveness and flexibility in business operations, which are underlined and hastened by the digital transformation orders brought out by the COVID-19 pandemic. This push toward digitization and automation is further pronounced, especially with the marked adoption of basic to advanced digital technologies by a good number of SMEs in the European Union, and as such, it is emphatically important (Moreir et al., 2023).

RPA has capitalised on digital information and organisational digital readiness to give an edge in the process of automation, and this has matured in rule-based processes. This not only increased efficiency but also allowed the employees to be engaged in far more creative and strategic tasks. The technology's ability to span various business processes and industries underscores its versatility and the broad applicability of automation strategies (Gartner., 2021).

Indeed, the pandemic has acted as a great accelerator for the adoption of RPA. The trend is that big businesses are going to have, by the year 2025, widespread utilisation of technologies for RPA. This is a way of streamlining digitally critical processes worldwide. The increase follows a bigger wave in which companies all over the globe turn to automation and ramp up digital strategies to stay competitive and operationally effective (Gartner., 2021). The global growth in RPA software revenue in the years 2019, 2020, and 2021 is shown in Table 1 below.

Year	2019	2020	2021
Revenue ($M)	1,411.1	1,579.5	1,888.1
Growth (%)	62.93	11.94	19.53

Table 1 Worldwide RPA Software Revenue (Millions of U.S. Dollars)(Gartner., 2021)

It's not only the operational roles of RPA, from digitization and data security to customer experience optimization, but also its adoption across functions to bring overall improvement in various forms of business operations. The integration of RPA with AI has further expanded its capabilities, leading to the development of IA. This broadens the scope of automation through the combining of technologies to allow decision-making from even unstructured and intricate analytic processes, therefore pushing the frontier of what may be automated (Ng et al., 2021).

Although immense potential has been seen with more and more organisations taking up its implementation, issues about the technology still persist. Issues such as deeper knowledge regarding the technology, characteristics of processes making them suitable for automation, and issues associated with its implementation. They comprise identifying processes with the highest digital readiness, lowest complexity, and repetitive nature and, therefore, are best placed for RPA execution. The transition of RPA to more advanced paradigms of automation, such as IA, is a milestone development, and such technology can bring further efficiency and strategic benefits to the organisation where these technologies are harnessed (Moreir et al., 2023).

With this increase in use of RPA, what does this mean for the military? RPA's full potential came forward with the introduction of Robotic and Autonomous Systems (RAS). RAS is a digital system or physical robot which is capable of carrying out tasks without any human interference (Jayakumar et al., 2021).

Studies have shown that military RAS applications range from teleoperation and semi-autonomous systems to fully autonomous operations, reflecting the varying levels of technological maturity and readiness. These systems are designed to enhance the operational effectiveness of military logistics, ensuring that critical supplies and support are delivered efficiently and safely to frontline units. The continuous evolution of RAS underscores their growing importance in military logistics (Ha et al., 2018).

An extensive study was done by The Hague Centre of Strategic Studies in the military applicability of robotic and autonomous systems. Each benefit displayed in Figure 4 is broken down in sub-criteria that seeks whether RAS solutions is beneficial for the military. The conclusion of this research is:

> "To summarize, this includes creating better and faster situational awareness and understanding, reducing the physical and cognitive loads of soldiers, sustaining and protecting the force, extending the reach and persistence of operations, increasing the pace of the OODA loop, and allowing the simultaneous execution of tasks for efficient action." (Torossian et al., 2021)

This reflects the potential for RAS, but with this implementation numerous challenges may arise. These potential challenges will be discussed in Section 2.2.4.
Given the magnitude of a military organisation it is impossible to give generic absolute levels of performance for each factor. Future research could seek for concrete applications to measure the relative performance of proposed RAS solutions to current human solutions

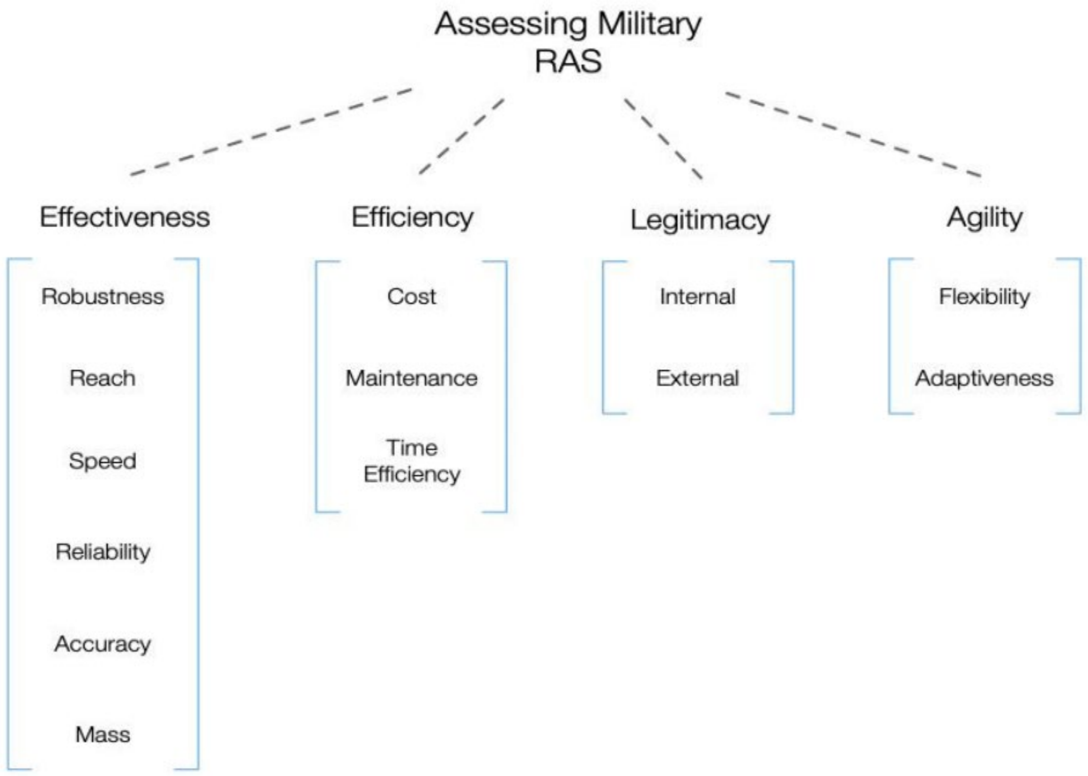


Figure 4 Evaluation Metrics used to Access RAS (Torossian et al., 2020)

2.2.3 Benefits of the implementation of RPA

The integration of Robotic Process Automation (RPA) into various sectors marks an important shift towards enhancing organisational resilience and operational efficiency, particularly in the context of digital transformation. As organisations and companies increasingly rely on digital technologies, RPA emerges as an important tool that enables the automation of business processes by substituting human effort with sophisticated software robots, thereby creating big changes across industries. The use of RPA in business comes with a list of considerable benefits that would improve the efficiency and effectiveness of your company or organisation. A detailed overview of the most important and effective benefits can be found in the research done by Moreira et al. (2023).

Improved operational efficiency:

Utilising RPA can significantly improve the operational efficiency of SCM by freeing up the human capacity within a process to ensure the human capabilities are used for undertaking strategic and analytics-focused activities. RPA excels at performing repetitive tasks within a process (Sutipitakwong & Jamsri, 2020). Ensuring repetitive tasks are done by RPA also decreases the overall error rate of the process (Lubis & Sembiring, 2023).

Using robots to automate a process would allow the execution of the supply chain processes without interruption, as it does not depend on the scheduling of human work, hence ensuring executing the processes repetitively without a break over a more constant flow. This is particularly advantageous in a military context where the need is erratic and time-bound. Therefore, such exactness and speed are often demanded.

The fact that RPA can easily integrate with an existing IT infrastructure (Choi et al, 2020), without drastic changes, would mean that improvements in operational efficiency are realised relatively quickly and only with the least disruption to ongoing activities. This integration is seamless in that the military processes are optimised without necessarily needing overhauls of systems or long downtimes to be affected. RPA technologies support data-driven insights in making a more informed decision-making process for the optimization of inventory levels, better forecasting of demand, and efficient allocation of resources. It drives more efficiency in that it ensures that more strategic supply chain operations benefit the overall mission effectiveness of strategic military operations.

Cost reduction

Cost reduction through the implementation of RPA in supply chain management is a multifaceted benefit that extends beyond just the reduction in labour costs. By automating routine and repetitive tasks, RPA minimises the need for human intervention, which translates into lower labour costs (Syed et al., 2020; Wewerka & Reichert, 2021). However, the financial benefits of RPA span several other dimensions:

- *Increased Accuracy and Lower Costs of Errors*
  Manual processes introduce the possibility of errors that may sometimes prove to be very costly to rectify. RPA dramatically cuts down on such possible errors by systematising processes, saving costs associated with refunds and the time that would be needed for dealing with unsatisfied customers.

- *Optimised Resource Utilisation*
  RPA enables organisations to make the most of their existing resources. By reallocating human resources from easy repetitive tasks to more strategic roles, companies can achieve better outcomes without additional hiring, thus optimising their workforce expenses.

- *Reduction in Training Costs*
  Training new employees or retraining existing ones on repetitive tasks can be both time-consuming and costly. With RPA handling these tasks, the need for such extensive training is greatly diminished, allowing for a more efficient use of training budgets for upskilling employees in more critical areas. Utilising this budget to train employees in more strategic roles can also increase the overall performance of a company.

- *Decreased Downtime and Maintenance Costs*
  RPA robots can operate 24/7 without breaks, reducing the downtime associated with manual processes. The maintenance of RPA systems, while necessary, is often less frequent and less costly than the upkeep and troubleshooting of manual processes or more complex IT systems.

- *Scalability Without a proportional Increase*
  As business needs grow, scaling manual processes often means a proportional increase in costs. RPA, on the other hand, can be scaled to handle increased loads with minimal additional costs, providing businesses with the agility to respond to market demands without a corresponding spike in expenses.

Increased accuracy

Incorporating Robotic Process Automation (RPA) into supply chain management significantly enhances data accuracy by automating data entry and processing tasks (Ng et al., 2021). The involvement of information technology in automating the system in this case reduces the chance of human error. Hence, the information saved in the system portrays the highest level of precision. Now, the RPA systems have rigorous rules and defined parameters to follow; meaning the process of execution is constant in the way it totally eliminates the variability that normally comes from human manual handling of data. The benefit of increased data accuracy extends to real-time data processing. RPA ensures that data is captured and updated in real-time to ensure that decisions in the supply chain emanate from the most current view and state. This is particularly valuable in scenarios that require quick turn-around, such as inventory management and order processing, in which the accuracy and timeliness of data have direct impacts on operational efficiency and customer satisfaction. RPA can, therefore, introduce checks and balances into its workflows that guarantee the maintainability of data integrity at each step. This will, in turn, not only bring down errors but also ensure that any anomalies are detected and corrected in time within the process.

Additionally, RPA's contribution to data accuracy facilitates better analytics and forecasting. Cleaner data, on the other hand, would ensure that models of analysis derived from it bring out more accurate insights, thus leading to better strategic decisions. For example, accurate demand forecasting heavily depends on historical sales data. Without it, any inaccuracy may lead to wrong predictions, thus resulting in overstocking or stockouts. The implementation of RPA in supply chain management transforms data handling processes, ensuring accuracy, consistency, and reliability of data. This will ensure that there is accurate, consistent, and reliable data through and through. It contributes significantly not only to the operational workflow process optimization but also to providing a strong base for strategic planning and decision-making, eventually helping to provide competitive advantages to the organisation (Wewerka & Reuchert, 2021).

Low technological barrier of RPA

The low technological barrier to implementing Robotic Process Automation (RPA) represents a significant advantage, especially in the context of supply chain management. Unlike most advanced technologies, which require significant changes in IT infrastructure and special skills for deployment, RPA has an integrated easy-to-use model. This level of accessibility is key for organisations looking to tap into the benefits of automation without the technical complications that come with it (Sobczak, 2019).

One of the key aspects of RPA's low technological barrier is its non-intrusive nature. RPA tools interact with current systems through the very same user interfaces used by human workers, meaning RPA requires profound changes in the underlying IT infrastructures. This can be a significant benefit for supply chain operations that depend on a combination of legacy systems and modern applications. RPA can bridge such systems with smoother data flows and the integration of processes without having to redevelop new IT systems.

The design of most RPA platforms incorporates easy and user-friendly interfaces, with many featuring a drag-and-drop capability for building and managing automation workflows. This democratises the development and maintenance of automation solutions, allowing non-technical staff, such as business analysts or supply chain managers, to participate in automation projects (Madakam et al., 2019). RPA's lower technical threshold means various users across the enterprise can engage, not just the IT department.

RPA's scalability also plays into its low technological barrier. Starting with small pilot projects to automate simple tasks, organisations can systematically extend the use of RPA to more complex processes as they build confidence and experience. This scalability, coupled with the company's ability to manage its technological adoption risk appropriately by spending gradually and scaling its automation capability in line with evolving needs and understanding, means companies can scale their processes without much struggle. There is also extensive support and community ecosystems around RPA technologies that make adoption even easier, from pre-built automation templates to comprehensive training programmes (Dey & Das, 2019). This ecosystem ensures organisations have the necessary knowledge and tools to implement and gain value from RPA, even when there is limited technical knowledge in-house. This means the low technological barrier of RPA offers an easier, friendlier pathway to automation in supply chain management, enabling organisations to improve efficiency, accuracy, and agility in their operations while minimising the disruption and resource investment typically associated with the adoption of new technologies.

Increased employee satisfaction

The induction of RPA into SCM workflows not only streamlines operations but also significantly enhances employee satisfaction (Sobszak, 2019). This boost in satisfaction is largely due to RPA's ability to relieve the human workforce from routine and monotonous tasks, thus improving job roles and the overall quality of work life.

RPA automates routine, time-consuming tasks, allowing human resources to focus on more valuable and engaging activities such as strategic planning, customer engagement, and problem-solving. This shift towards more interesting and rewarding work environments, as employees are better positioned to utilise their unique human capabilities and creativity, could potentially reduce high turnover rates. When employees are engaged in less monotonous manual work, their risk of burnout or job dissatisfaction decreases, leading to a more motivated and active workforce (Reddy et al., 2019).

Moreover, RPA's impact on reducing errors and enhancing process efficiency can contribute to a more positive workplace culture. Employees often face frustration and stress from correcting manual errors and dealing with inefficiency issues. By minimising such problems, RPA facilitates a smoother and more reliable workflow, significantly improving overall job satisfaction and team morale while reducing the burden on employees. RPA also empowers employees in terms of professional development. With RPA handling routine tasks, employees have more opportunities to acquire new skills and competencies in areas like digital transformation and process optimization. This not only enhances their career prospects but also contributes to a sense of achievement and fulfilment at work.

The successful implementation of RPA projects can foster a culture of innovation and continuous improvement within the organisation. Employees directly involved in identifying automation opportunities and developing RPA solutions are likely to feel a greater sense of ownership and contribution towards the organization's success. Such involvement in transformative projects can heighten their commitment to the company and increase their engagement and satisfaction.
By efficiently handling routine and repetitive tasks, improving job roles, and offering more opportunities for professional development, RPA leads to a more fulfilling working environment. This not only benefits employees in terms of their work morale and career progression but also empowers the organisation with a more motivated, committed, and competent workforce.

Non-invasive technology
Non-invasive technology refers to solutions that integrate seamlessly with existing systems without requiring significant modifications within the IT landscape. The military supply chain requires high levels of reliability and stability. Non-invasive RPA tools interact with current systems through the same user interfaces used by the same employees. This means RPA can be implemented without significant changes to the underlying infrastructure (Sobszak, 2019). This creates a minimal amount of disruption within the supply chain. This factor of IA highly correlates with the increase in efficiency due to the fact that it can easily be integrated within an existing IT-landscape. As mentioned, a supply chain can continue without significant changes to the IT landscape, and employees can continue their tasks with additional help from robots. Whereas if a robot takes over the task, this employee will be assigned new tasks, which will cost additional training costs and slow down the entire process (Wewerka & Reichert, 2021).

2.2.4 Challenges in RPA deployment
The deployment of RPA has the potential for a significant increase in efficiency, accuracy, and productivity in business operations. However, using RPA technologies in established systems and workflows presents certain challenges. This section, "Challenges in RPA Deployment," aims to discuss the different obstacles companies and organisations might face when adopting these technologies. Understanding these challenges and considerations is essential for having a smooth RPA deployment that fulfils the anticipated outcomes.

Mistrust in RPA
The mistrust in RPA, especially in the domain of SCM, is deeply rooted in a variety of operational and strategic concerns (Flechsig et al., 2022). In the article written by Flechsig, these concerns are mentioned, one of those concerns is that organisations grapple with the scary prospect of integrating RPA into their existing technological frameworks. This integration challenge sparks the fear of potential disruptions and the complexities that might cause them, leading to a hesitance to fully embrace RPA. As discussed, RPA cannot be used to automate every kind of process, certain requirements need to be met. For RPA to work at its best, certain input needs to be given to the software robots, if this is done insufficiently, the results given by these robots could be disappointing.

In the public sector, organisations admitted their ignorance of RPA and lamented missing input from consultancies and vendors. This was drawn from the sample size in the research done by Flechsig et al. (2022). Since RPA, most of the time, relies on the input of employees, an understanding of the software needs to be present in order to supply the correct information. A private company mentioned in the study was disillusioned since the technology turned out to be unsuitable for specific processes. This triggered extra-long implementation cycles with similar automation software due to the department's inadequate requirements, which is why trust in the technology of RPA is not always there.

The phrase "if it ain't broke, don't fix it" is well known in military organisations. In the military, people tend to stay for a significant number of years due to patriotism. This causes employees to often do the same line of work for a number of years. As shown by Flechsig et al. (2022) in public sector companies, where this phenomenon is also the case, elderly colleagues are afraid of being made redundant or given undesirable new responsibilities.

Building trust and gaining acceptance is crucial, as employee hesitations often represent a major obstacle to implementation. User resistance can stem from various sources, such as an increased workload during the project, reduced autonomy and recognition, a lack of confidence in the bot's results, or a broader apprehension towards change and digitalization. Inadequate transparency and communication across departments can delay the effective adoption of RPA.

Cost of the adopted RPA tool

Implementing new technologies is always an investment in the future of your company or organisation. Prior to the decision, several calculations will be made to see if this investment is worth the money. A challenge when implementing RPA technology is that the true costs of RPA are often misunderstood and underestimated (Euleich et al., 2022). Employees often report certain business cases where RPA has saved labour hours and reduced errors. The problem is often that these reports do not include the costs related to the ongoing monitoring, assurance, and security measures for the robots. In the research done by Euleich et al. (2022), more than 20 people in high-ranked company positions were interviewed about the challenges of RPA implementation. One interviewee said:

> *" Of course, the security problems are eventually resolved and this costs a lot of money and interestingly, in the beginning we thought, 'well this is a very cheap service and we can sell it to everybody', but with all the security measures now, it's no longer a cheap service…"* Euleich et al. (2022)

This reflects the overall view of how companies may look at the total cost of the implementation of RPA. Since financial numbers are often one of the most important decision and prioritisation criteria for management, this requires a detailed breakdown of the total costs of the implementation. If this is a challenging task for a company, this could be a reason for overseeing this technology (Reddy et al., 2019).

Knowledge loss

To execute a process correctly, you need the proper process knowledge. Multiple factors come into play, for instance, the interaction between two different applications. The power of RPA is the ability to relieve some of these factors from the employee who originally performed the work, which could also be a disadvantage. If the implementation of RPA is done correctly, the original employee has little to no interaction with the software robot who is performing the process. When this is the case, the potential for knowledge loss regarding the process is there. This loss can be divided into two dimensions. First, the loss of domain knowledge regarding the underlying business processes, as the software robots are these processes instead of the employees. If entire processes are done by software robots, the organisation could lose the ability to perform the process by hand. The second dimension is knowledge loss, which is created when an employee who created and maintained the software robot leaves the company or organisation. Therefore, it is important that if this occurs, the handover of information is done correctly and extensively and that the documentation regarding the process and software robot is sufficient (Euleich et al., 2022).

2.3 Artificial Intelligence: Transforming Military Supply Chains

Artificial Intelligence AI has become an important technology in modern operations, offering transformative potential across various sectors. This section begins by discussing the key characteristics of AI. Understanding these foundational aspects sets the stage for exploring AI's role in automation.

Next, the focus shifts to the role of AI in automating complex processes. This includes an examination of how AI can enhance efficiency, accuracy, and responsiveness within military supply chains. With the use of AI, additional security considerations may come into play, which will also be discussed in this section.

2.3.1 Characteristics of AI technologies

Artificial Intelligence (AI) is a multidisciplinary computer science discipline interested in the creation of computers developed to imitate or simulate human intervention. These systems either mimic or imitate human mental processes like learning, problem-solving, and decision-making, among others. One of the main characteristics of AI is the ability to process huge amounts of data, understand complicated patterns in this data, and then make decisions based on these patterns, which are beyond human speed and precision.

AI technology basically capitalises on the power of computational algorithms to enable machines to learn and interpret data by being flexible and adapting information to make decisions and accomplish specific goals and tasks. This definition underscores the fact that AI systems are dynamic and adaptive: the systems expand in their performance and grow with time by learning through experience with new data (Banafa, 2024).

The conceptualization of AI has morphed radically from its formal inception in the middle of the 20th century. AI originally sought tasks that may have demanded intellectual effort if done by a human being, such as arithmetic or playing chess, to automate. Long-term development has seen attention shift towards building systems that could be capable not only of replicating human tasks but also of learning and adapting. Carrying out a kind of intelligence not to mimic but inherently adaptive, dealing with complex, ill-defined problems (Mitchell, 2006). AI can simulate human intelligence in areas far more complex than simple computation or logical thinking. The area touches on the subtleties of human cognition, ranging from understanding languages to recognising emotions and even finding or making ethically founded choices (Hamet & Tremblay, 2017). This breadth of capability has, therefore, seen AI applied in a broad array of domains: from the very mundane, like sorting emails, to the genuinely critical applications, such as diagnosing diseases or navigating an autonomous vehicle, and even formulating legal arguments.

AI is a scientific field based on its development and application, which concentrates on psychology, mathematics, and even some parts of neuroscience. The more it broadens the limits of machine capability to make systems do things that were once in the realm of tasks best handled by human intelligence,. All these continuous advancements in AI raise some important considerations about the nature of intelligence, the future of the interaction between humans and machines, and its ethical consequences regarding autonomous systems deciding things that could radically alter human lives and society.

A number of key technologies and methodologies underpin the field of AI, each bringing its own contribution to developing intelligent systems capable of doing complex work.

Machine Learning:
Arguably at the core of AI is Machine Learning (ML), ML will contain computer-based algorithms that enable data learning while offering predictive or decision-making abilities regarding the given information. In traditional programming, algorithms are hard-coded to perform certain tasks. This is different from ML algorithms; rather, they offer an opportunity for the system to enhance performance over time when exposed to more data. The possibilities for the use of ML are endless, therefor it is widely used in SCM. In a paper done by Aljohani (2023), the integration of predictive analytics and machine learning to enhance supply chain agility and risk management was researched. This research focused on multiple factors within the supply chain, such as adaptive decision-making; data collection; predictive analytics; early warning systems, and risk impact assessment. In each of the categories, an improvement was concluded in the efficiency of all factors. Accuracy, quality control, and precision increased, and total production and response time decreased. A case study was done where this framework was implemented in the automotive industry. The predictive models enabled the identification of potential material shortages and allowed proactive adjustments, preventing costly delays and maintaining production efficiency. This is an example of the effective use of the AI technology, ML.

Deep Learning:
Deep learning is a subfield of AI and neural networks focused on processing a huge amount of data with large-scale neural networks. It has proven particularly useful for tasks ranging from image recognition to speech recognition and natural language processing. It enabled the extraction and training of very complex, explicit patterns and features that are beyond the ability of a human coder to encode. Again, the possibilities are endless, as researched in the systematic literature review done by Shavaki and Ghahnavieh (2022). In this research, a total of 43 studies were examined to identify the types of SCM problems addressed using Deep learning, the specific Deep learning algorithms applied, and their performance compared to alternative techniques. Numerous implementations of Deep Learning techniques can be found in this research. The key finding here was that the integration of Deep Learning significantly enhanced the efficiency and effectiveness of SCM. The most promising areas; are quality management and forecasting, which are also two prominent factors in MSCM.

Computer Vision:
A subfield of computer science where the field brings methods on how to enable a machine to interpret and act rationally over visual data. A computer vision system fuelled with AI is a system that enables recognition in images and videos of objects, faces, scenes, activities, etc. It empowers machines, though normally with faster speed and more accuracy, to do what human vision accomplishes in interpreting and acting rationally over visual data. Within SCM, this technology can be used to increase quality control when manufacturing and distributing products. Ettalibi et al. (2024) review in their research the applications of AI and Computer Vision in real-time quality control within the industrial sector. Being able to not only be more accurate in quality control but also be more responsive when errors occur was found to be a significant enhancement of the SCM. A different case study of Computer Vision being utilised in increasing quality control within SCM is discussed in 2.3.2.

The incorporation of AI technologies into military supply chains offers multiple benefits, including enhanced efficiency, accuracy, and responsiveness. Due to the nature of operations performed by the military these benefits can make a significant difference. For example take the response time of a system when a cyber-attacks occurs, having this additional increase in responsiveness could be crucial. By leveraging these technologies, military logistics can achieve significant improvements in operational performance and readiness. These technologies enable the processing of large amounts of data, the identification of complex patterns, and ensuring that military supply chains are equipped to meet the demands of modern warfare. The technologies discussed above are examples of those that can be incorporated into MSCM. A complete taxonomy of the different AI technologies can be found in Figure 4.

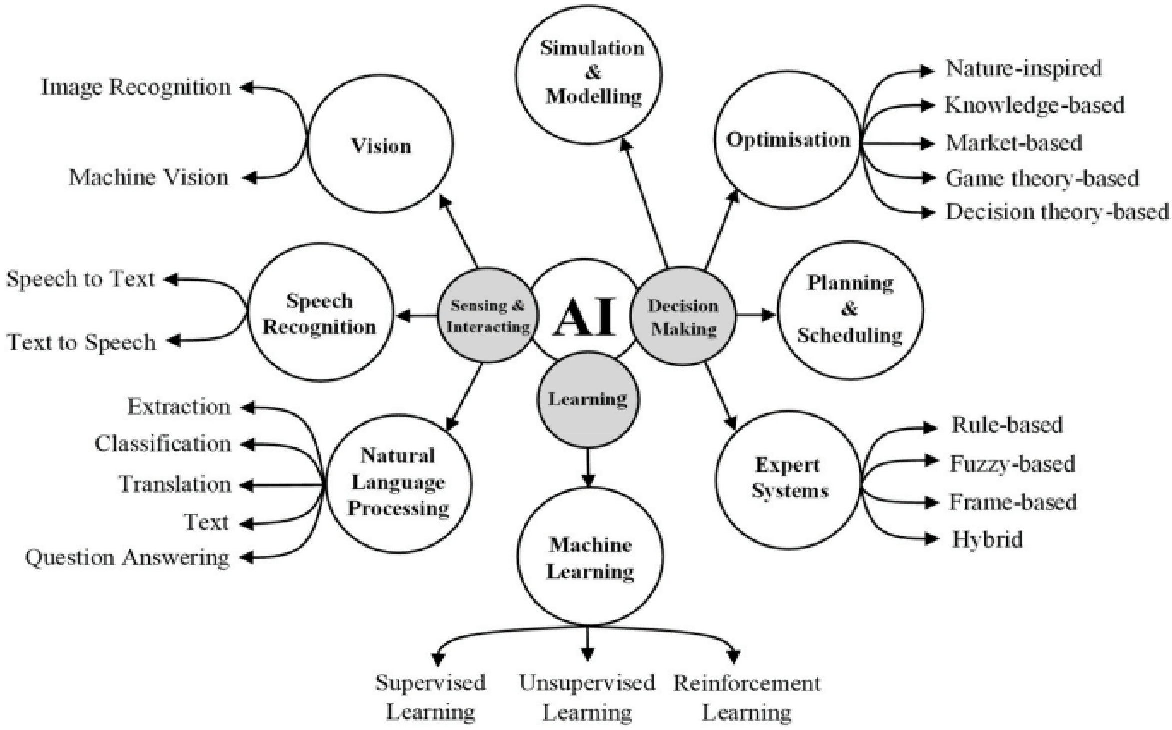


Figure 5 AI taxonomy, Artificial intelligence applications in supply chain management

2.3.2 AI Technologies in automating the supply chain

AI is increasingly becoming a cornerstone in military strategy and operations, offering transformative capabilities across various domains. The application of AI in the military context is diverse, ranging from strategic planning to tactical operations, and presents both opportunities and challenges (Dash et al. 2019).

Predictive analytics

It is an advanced form of analytics that uses plenty of statistics, modelling, data mining, and machine learning techniques for the purpose of finding out predictions on future or otherwise unknown events on the basis of analysis conducted against current and historical facts. This is the science of extracting information from data with the intention of predicting trends and behaviour patterns (Han et al., 2011). Often, the unknown event of interest is in the future, while predictive analytics can apply to any type of unknown, whether it be in the past, present, or future. Predictive analytics models are related to principles and include mathematical models and computational algorithms that help find patterns in relations between input data sets. They range from simple regression analysis to complex neural networks and deep learning models. They, therefore, depend on the nature of the data, the kind of prediction that needs to be carried out, and the level of accuracy these predictions call for (James et al., 2013).

The key steps in predictive analytics include:

1. **Data Collection**: Gathering historical data from the system, which may consist of any variable believed to have influenced the future result.
2. **Data Preparation**: Cleaning and pre-processing the data to handle missing values, outliers, and to ensure data quality.
3. **Feature Selection**: Identifying the most relevant variables that are predictive of future outcomes.
4. **Model Building**: Selecting and applying statistical or machine learning models to the prepared data.
5. **Validation and Testing**: Evaluating the model's performance using a separate dataset to ensure its predictive accuracy.
6. **Deployment**: Implementing the model in a real-world scenario to make predictions.

Predictive analytics is based on the understanding that the history of data patterns and trends may have potential outcomes. This is encapsulated through the idea "that history always repeats itself," except for the fact that it further adds predictive models that can capture complex relationships that are likely elusive for human observers (Bishop, 2006). Its value in predictive analytics goes beyond simply predicting and forecasting future events with accuracy; it provides actionable insight.
In military logistics an specific example which is currently been used is using AI for predictive aircraft maintenance (Weisgerber, 2017). Instead of making repairs when an aircraft is damaged or has a faulty part, the United States Air Force is standardising fleet-wide maintenance schedules. This technology uses real-time data embedded in the aircraft to feed the predictive algorithm the data it need to determine whether maintenance is needed (Sayler, 2017).

Forecasting demand
AI is significantly enhancing projection and forecasting, which is crucial for organisations striving to balance supply and demand. This advanced forecasting is vital for optimising supply chains and manufacturing processes. AI excels at processing, analysing, and predicting data, this will then provide an accurate and reliable demand forecast. This capability enables businesses and organisations to fine-tune their procurement and order processing, thereby reducing costs associated with transportation, warehousing, and overall supply chain management. AI also plays a key role in identifying trends and patterns, which aids in developing superior retailing and manufacturing strategies. For instance, businesses use AI to precisely stock the quantities of products they are likely to sell, minimising waste and cost. Accurate sales trend data allows them to stock up on items expected to become popular, ensuring they do not miss sales due to product unavailability.

An excellent example of the smart use of AI to forecast demand is the current use of AI by Walmart. One of the reasons for the large success of Walmart is the use of AI in not just one domain but in several domains such as inventory management, supply chain management, pricing, customer service, and fraud detection (Here, 2023).

The given example proves that forecasting demand can improve commercial SCM but what does this mean for military supply chain, given the differences between these two. Research done by Okechukwu et al. (2020) compared various machine learning algorithms for predicting availability and the reorder level of military logistics. The results of this evaluation was that multiple algorithms performed above 78% such as artificial neural network and logistic regression. If used in military logistic, there could be significant improvement in: meeting production and demand targets or proactive supply chain and value chain derivations.

Quality control of products

The supply chain of a company or organisation is a large section dedicated to the production of goods. The analysis needed to check if these products meet standards can be done by various AI technologies. A case study done by Helo and Hao (2021) researched the use of these technologies when this analysis was done by visual inspection. AI-based stream analysis can pick up certain flaws in the quality and/or packaging of the product. These AI cameras are linked to a deep neural network (DNN). Having access to a DNN produces a high accuracy rate, but it also has the ability to train new product features in a relatively short time. Figure 5 below illustrates a high-level overview of how the local cameras integrate in real-time with the DNN to detect pre-trained quality features of the product. A DNN detector can be trained to recognise a large variety of product errors and understand if there is a deviation from the quality standard or if the product rotation is different from the expected one. The main objective of this quality control case was to move from sampled quality control to a 100% inspection rate without the need for extra personnel. Also reducing the amount of waste in the entire process and building a systemic learning loop on quality assurance results from production and earlier parts of the process.

The quality of products in the MSC is essential due to the critical nature of military operations where equipment reliability, safety, and effectiveness are non-negotiable. The readiness and overall capability of the armed forces directly correlate to the high-quality materials and equipment they receive. Inadequate quality can lead to equipment failure, jeopardising missions and endangering the lives of the soldiers. Therefore, strict quality control measures, rigorous testing, and continuous monitoring are a must in the MSC (Yang et al., 2024).

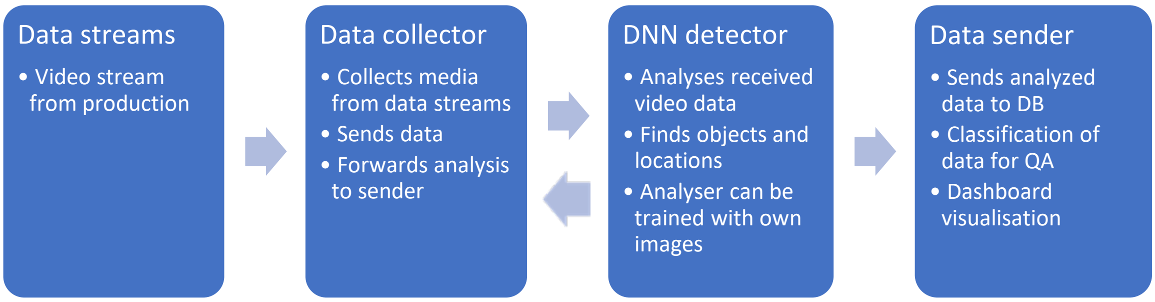


Figure 6 Feature detection for quality control through machine vision and DNN (Helo and Hoa, 2021)

The systematic literature review done by Toorajipour et al. (2021) into the possible implementations of AI technologies in supply chain management showed that significant improvements can be made using a number of different technologies. In this literature review, 64 articles were analysed to determine what AI methods were used to improve SCM. In table 2 all different fields are shown with the AI corresponding AI technologies. The number of times the different technologies were used in the found literature is noted behind each AI method. This goes to show how important these AI technologies are and the extensive fashion in which they have already been utilised.

It also shows the numerous ways these AI technologies can be implemented in order to improve MSCM. In the research done by Toorajipour et al. (2021), far more information regarding the use of AI technologies in different fields of SCM and their corresponding articles can be found.

Field	AI Technique
Marketing	Artificial neural networks (4)
	Generic algorithm (4)
	FL/modelling (3)
	Agent-based/multi-agent systems (2)
	Swarm intelligence (1)
	Simulated annealing(1)
	Association rule (1)
	Tree-based models (1)
	Support vector machines (1)
	General forms of AI (1)
	k-means clustering (1)
	Hill climbing (1)
Logistics	Artificial neural networks (1)
	Agent-based/multi-agent systems (1)
	Data mining (1)
	Simulated annealing (1)
	Automated planning (1)
	Robot programming (1)
	General form of AI (1)
	Heuristics (1)
Production	Artificial neural networks (8)
	FL/modelling (5)
	Case-based reasoning (4)
	Generic algorithm (3)
	Agent-based/multi-agent systems (2)
	Data mining (2)
	Decision trees (2)
	General forms of IA (1)
	Gaussian (1)
	Rule-based reasoning (1)
	Automated planning (1)
	Swarm intelligence (1)
	Expert systems (1)
Supply chain	Artificial neural networks (5)
	FL/modelling (4)
	Agent-based/multi-agent systems (4)
	General forms of AI (4)
	Physarum model (1)
	Bayesian networks (1)
	Swarm intelligence (1)
	Data mining (1)
	Support vector machines (1)
	Stochastic simulation (1)

Table 2 Categorisation of AI techniques based on field (Tourajipour et al, 2021)

2.3.3 Ethical considerations

Long before the dawn of modern robotics, stories of human-created beings turning against their makers have captivated our imaginations. This theme has not only persisted but has also evolved with technological advancements. From the philosophical musings of early 20th-century writers like Stanislaw Lem to the cautionary tales of Isaac Asimov, fiction has long grappled with the ethical and practical challenges of AI.

As the 1900s progressed, interest in computing and robotics grew, which brought new life into these narratives. Films like "The Terminator" and "The Matrix" introduced a wider audience to the thrilling and sometimes terrifying possibilities of AI. These stories presented a future where machines equipped with AI surpass human capabilities and potentially threaten our existence.

While these stories capture the imagination, they also shape real-world policy discussions. The dramatic scenarios they paint are not just entertaining; they provoke thought, raise awareness, and sometimes even drive action among policymakers and technologists. Indeed, such narratives have been pivotal in fostering international dialogue aimed at curbing the development and deployment of potentially harmful AI technologies.

However, it’s not just filmmakers and authors who are sounding the alarm. AI experts and tech companies themselves are increasingly vocal about the potential risks associated with advanced AI systems. Their concerns, combined with those depicted in fiction, underscore the broad spectrum of voices contributing to this critical conversation.

As AI weaves itself deeper into the fabric of our daily lives, the ethical stakes continue to grow. Whether it's improving patient care in healthcare, streamlining transactions in finance, or enhancing public safety in law enforcement, AI's reach is expanding. The ethical challenges that accompany these advancements are not to be taken lightly. Several of the topics associated with ethical considerations are of even higher importance in the military, as will be discussed below (Hurriye, 2023; Safdar et al., 2020).

To increase the use of ethical AI in automation, several papers have suggested frameworks that aim to identify potential ethical challenges and propose some remedies to overcome those challenges. These frameworks could offer key concepts for addressing the ethical dimensions of AI systems and their possible effects, identify important ethical principles and issues, and detail regulations (in the context of legal frameworks) or solutions for managing them. These guidelines typically outline the ideal design of AI systems or warn about potential risks. The conceptual aspect focuses on explaining the ideas behind ethical principles, such as the concepts of bias and fairness in AI systems. These principles often embody the qualities that AI systems should possess, like transparency, data privacy during AI development, or the preservation of human dignity in AI applications. An extensive overview of these ethical frameworks can be found in the review of approaches by Erich Prem (2023).

Not only can AI be used to improve backoffice processes, but nowadays it can also be used in lethal autonomous weapons. These pose an ethical problem since the systems can continue and act without human input. The independent, targeted, and engaging objectives, which are not dependent on humans, violate the basic notions of war and accountability, among other humanitarian laws. Therefore, a big concern in the use of this type of AI is liability.

Autonomous weapons make it almost impossible to trace the line of decisions taking place within the battlefield and hence who, if at all, should be held to account for decisions made and actions performed by such systems (Morgan et al., 2020). Such a lack of clear accountability tends to raise concerns about violations of international humanitarian law. More specifically, the principles of distinction and proportionality tend to call on the combatants to distinguish between civilians and combatants, further ensuring that the violence applied is proportional to the advantage gained.

On the other side, the deployment of fully autonomous weapons can be a source of strategic change on the battlefield. Its usage would lower the conflict threshold, as decisions are made at a swifter pace without having to rely on direct human supervision. This is likely to lead to an escalation of warfare and a new arms race in the technology of military applications.

This risk is further heightened by the velocity and lack of transparency inherent to how autonomous systems may operate, which, unchecked, could produce unintended engagements or escalations that human operators might otherwise have avoided. But for all these concerns, a very strong push from many military leaders and policymakers themselves remains to push forward with the development of autonomous weapons systems (Schwarz, 2021). All of that will need international discussion and treaties that really set bounds and standards for such technology, making sure that the development of military AI doesn't outstrip our ethical frameworks and legal norms. This ongoing debate on whether or not to use autonomous weapons in warfare does not take away the fact that AI could improve the efficiency and effectiveness of the military. As mentioned by Meerveld et al. (2023) AI could be used for much more than just autonomous weapons.

As discussed in this research, automation can make a huge impact. Meerveld et al. (2023) researched the use of AI in the military decision-making process. Given the limitations of human decision-making, the advantages gained from AI (partial) automation can be found in the timely dimension and in decision quality. AI can help automate manual tasks, identify patterns, and accelerate the process of decision-making. This is research by a NATO Research Task Group (NATO, Science & Technology Organization, 2020).

2.4 Features and Applications of Intelligent Automation

Having discussed the benefits and challenges of AI and RPA, the combined technology of these two is called Intelligent Automation (IA). RPA is well known for its effectiveness in repetitive tasks without the interaction of human handling, and AI is well known for its ability to replicate the cognitive functions of a human. The combination of these two technologies can have a significant impact on the efficiency and accuracy of a military supply chain. In this next chapter, all the benefits and challenges of IA will be discussed.

2.4.1 What is automation?

Digital manufacturing, smart factories, and the Industry 4.0 initiative all share common organisational transformations driven by the adoption of technologies and devices. These technologies are capable of autonomous interaction with each other and with individuals throughout the value chain. This transformation was possible due to the technical progress that was made in the following areas (Coito et al., 2017):

- Cyber-physical systems (CPS)
  This covers the integration of physical and decision support systems, collaborative robotics, robotic process automation and predictive analytics (Alguliyev et al., 2018)

- Internet of Things (IoT)
  This is known as the infrastructure of the information society by the International Telecommunications Union. This refers to that all devices are expected to be connected to the internet and to each other. Therefore making the transfer of information easier and more common

- Cloud-based solutions and edge computing
  This is the ability to provide access to big data platforms and computational power while having a decentralised IT infrastructure within the company (Wang et al., 2023)

- Big data warehousing (BDW)
  Providing large and state-of-the-art technology to store and retrieve big data in a decentralised environment. This works in close contact with cloud-based solutions and edge computing (Krishan, 2013).

- Digital twins
  This is the ability to recreate a digital version of a physical environment to create simulation models (Qian et al., 2022).

With the introduction of Industry 4.0 intelligent automation took on a new form with a combination of artificial intelligence and automation. Creating all digital technologies towards the automation of processes, assisted by analytics and decisions made by AI.

A standard framework is delivered by the International Society of Automation (ISA-95, International Society Of Automation, z.d.), this illustrates the data-driven industrial interfaces between the bottom layer of a company and the top, as displayed in Figure 6 (left). Each of these layers has the potential to be improved by the implementation of IA and affect the supply chain within a company or organisation:

- **Level 0** is constructed out of the actual physical processes and the most basic manufacturing operations are active. This includes machines and equipment that accomplish production operations and involve means of conveyance, robots, and other devices for direct participation in the production, handling, and assembly of products. Sensors and actuators that gather and control process parameters operate at this level. An implementation of the technology displayed in Figure 6 could be beneficial to increasing the productivity at this level.

- **Level 1** includes all devices and technologies directly involved in controlling the physical process. Programmable Logic Controllers (PLC) are known for their reliability these device types include sensors, actuators, and related hardware that manage a particular function or operation on the factory floor. These devices collect the data originating from the field and control the operations in real-time, ensuring that the process limits within temperature, pressure, and motion are not violated.

- **Level 2** has a focus on the control of multiple machines or a segment of the manufacturing process. Level 2 systems aggregate data from Level 1 controllers in coordination with other Level 2 controllers. An example of a level 2 task may be the whole operation of a production line or functional area of the factory. Systems, including Supervisory Control and Data Acquisition (SCADA) systems, Human-Machine Interface (HMI) systems, and other systems that provide visibility to operations for management, are at this level.

- **Level 3** comprises the systems that manage production operations plant-wide. Including the management of production scheduling, batch management, software, and systems for plant-wide material flow and plant manufacturing execution. It links the operating details of the plant with higher levels of planning at the enterprise regarding the goal that production should support business objectives. The systems at this level generally communicate with level two control systems as well as level four enterprise systems, which include integration of process control with business logistics.

- **Level 4** is comprised of the enterprise level, whereby systems manage the whole of the manufacturing organisation beyond a single plant. Level 4 systems include Enterprise Resource Planning (ERP), Supply Chain Management, and, generally, all corporate activities. At this level of information, the system focuses on strategic planning and resource management, which comprises finance, human resources, and processes for order fulfilment. The data at this level of information informs overall business performance and the ability to make decisions on strategy.

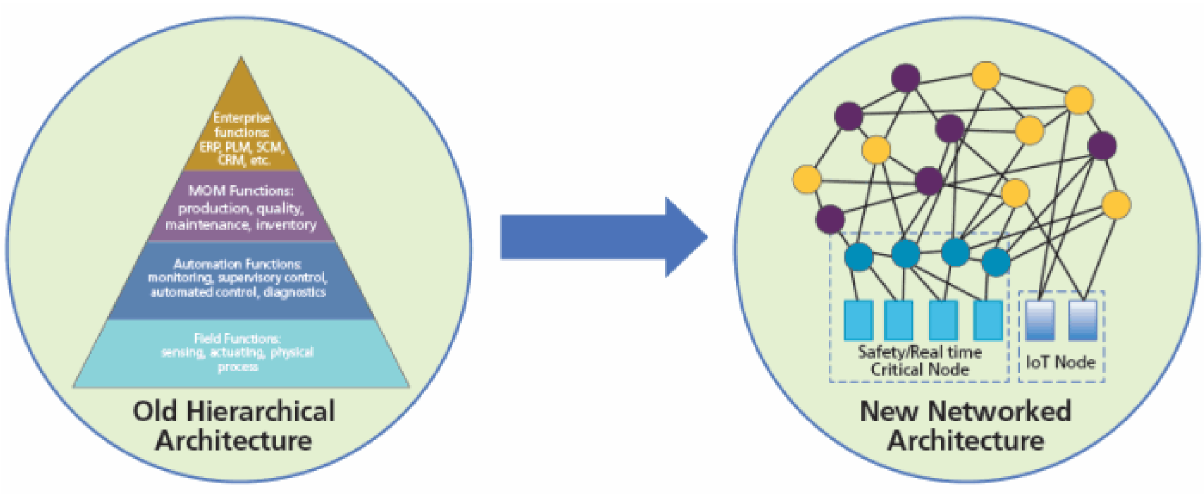


Figure 7 Model evolution: Hierarchical pyramid (left) to network structured architecture (right) International Society of Automation (ISA)

This framework is designed with a horizontal information transaction where the information is transmitted from floor to floor. To make a sufficient intelligent framework, it is paramount to increase communication and decentralisation. The standard platform used to exchange data between software and devices in real-time is the open platform communications-unified architecture (OPC-UA) (Busboom, 2024). OPC UA is widely known for being a key enabler of "Industry 4.0" and one of the most promising standardised platforms for communications from sensor to cloud. OPC UA is a protocol designed for secure and reliable exchange of data between industrial environments. It is built upon a Service-Oriented Architecture (SOA) which allows different parts of the industrial system to communicate through a robust set of services. The core of OPC UA is defined by the use of structured information modelling, which allows for complex data and their relationships to be modelled and communicated in a standard way. This information transfer is not only real-time but also highly secured via the use of TCP/IP or HTTPS. As mentioned, using the intelligent automation framework designed by Coito et al. (2017) real-time data access across all layers of the system enables the peak performance of this framework. The use of OPC UA creates these data ports and transforms the hierarchical pyramid (Figure 6, left) to the network architecture (Figure 6, right).

The design of OPC UA supports scalability and security, making it an ideal choice for industries looking to adopt intelligent automation solutions. The effectiveness of OPC UA in such environments hinges on specific characteristics of the information and the underlying IA systems. These characteristics will be addressed in sections 2.4.2 and section 2.4.3.

2.4.2 Features of Intelligent Automation

Certain features of IA need to be present in order to be a solution to certain dimensions of the problem in supply chain management. The guidelines of these features will be discussed below

Responsiveness:

Responsiveness in IA refers to a system’s ability to quickly gather, process, and respond to data. The setup is made for processing real-time data streams that facilitate immediate action in response to changes in operations. This means that the traditional hierarchical structures of data flow are bypassed to allow direct communication between sensors and actuators while also reducing the delay in decision-making. This becomes very important in industries characterised by rapidly changing conditions since any delay may result in greater inefficiency or even pose a danger to safety (O’Rourke, 2014; Josyula et al., 2021). It increases the agility and efficiency of automated systems by improving how information moves as well as how decisions are made.

Key factors of MSCM are adaptability and resilience, as mentioned in 2.1.2, increased responsiveness helps by increasing these factors. This makes SCM more agile and thus easier to adapt to unpredicted chances.

Digitalisation

The process of changing information from physical forms into digital forms is called digitalization. This increases the functionality of data and its usability. Digitalization allows businesses to use advanced technologies like digital twins, which are simulations of real-world processes and environments (Srai et al., 2019). By converting information into digital formats, organisations can analyse large amounts of data more easily. This helps improve the accuracy of their computer models and their overall efficiency in operations. Digitalization aids in implementing Industry 4.0 technologies such as 3D printing or virtual and augmented reality (Pozzi et al., 2021). It enables better integration and analysis of data, which is crucial for developing predictive maintenance plans and improving system reliability. Digitalization also ensures that information does not reside in key people within the supply chain, but rather that their knowledge can be accessed by authorised people within that same supply chain.

Interoperability

For the business sector, smart robotics needs the ability to work together with other systems. This will enable efficient communication between the machines and the exchange of important information. It should allow all kinds of devices to interact seamlessly without much customization or manual input, including outdated tools and modern applications. Integration complexities can be greatly reduced by using well-known standards like OPC-UA (Busboom, 2024) as discussed in Section 2.4.1. Not only does this support brownfield environments where old systems have to communicate with new technologies, but it also ensures easier upgrades for future expansions (Etz et al., 2020). Maintaining effective operations depends on such interoperability because companies can adapt easily to changing technological landscapes, which makes them foundational in any intelligent automation framework.

Traceability

The ability to monitor the processes and available resources throughout their life cycle. It is the capability to determine and follow the movement and history of things to, in, and throughout the supply chain. Following each order, all products are traced, and standards are maintained. This capability is of critical importance in some industries where quality and compliance are the order of the day. Better traceability can thus help enable more transparent operations, like quick issue identification, which can otherwise reduce downtime and improve quality (Guo et al., 2014). This will also allow more accurate data collection for further research and compliance with regulations.

2.4.3 Data characteristics

For successful IA used in SCM, one has to retrieve data that is relevant. It comes with necessary data characteristics, which can be divided into two categories: operational data and process data. Operational data refers to all the data that would be gathered, processed, and stored in routine business operations. Sufficient and relevant operational data is key to data process improvement and metric outputs. However, its accumulation requires a focus on the dimension of time from the beginning to get them accurately. Therefore, temporal data acquisition, whether event-based or periodic-based, is necessary. Some of the measures for getting event-based data include identification systems, alarms, production orders, or material consumption. Periodic-based data captures states over time, for example, various resources on the ground, changes in location resources, or changes in sensors. Such a type of data gathers transaction data and time series that offer traceability and give key performance indicators. Such data supports decision tools like dynamic scheduling algorithms and predictive maintenance, which have a direct impact on the internal supply chain.

Process data, on the other hand, can be explained as information about the business model of an organisation, workflows, structures of data, and other necessary relationships vital for operations. Since business processes have evolved, it is pragmatic to have adaptive models. Proper acquisition process data allows for mapping the business and structuring representation models in the form of digital twins. In addition, the capture and parameterization of constraints (physical, exceptions, priorities, shifts, resource competencies, and business rules) enhanced scalability and flexibility, aiding dynamic scheduling and adaptation to changes. For that reason, the data used for the proper operation of the IA has to meet both origin: operational and process and hold the specific characteristics of responsiveness, digitalization, interoperability, and traceability.

When these two forms of data are collected, they need to comply with certain characteristics to optimally use IA. Data is commonly defined by its volume, velocity, and variety as the 3Vs of big data (Larson & Chang, 2016). The framework created by Coito et al. (2017) proposed guidelines for the following characteristics:

- *Quantity*: Records that can have no periodicity, such as production orders or event-based triggers. Still, they can be periodic with high granularity requirements, for example, on a second or millisecond time frame. The volume of data generated may require an ever-growing and changing infrastructure. The data model's architecture must be properly prepared for scaling, moving data into metadata alternatives, and including database indexation.

- *Frequency*: The speed at which data must be stored, processed, and delivered. Lower frequencies are often used to fetch information from databases and/or data warehouses, while higher frequencies are common on applications set to track, perform analysis, and deliver results in real-time settings. Real-time is becoming standard in industrial applications. There is a need to find a compromise between the processing capabilities of each frequency and what is possible. The ever-changing threshold of what granularity is a must and what is not.

- *Variety*: Data may contain simple and well-structured tables with numbers, text, and dates or may be complex and contain unstructured data that comes from files of audio, image, video, or other types. All the data needed to make an application run should be fetched, pre-processed, and brought together into a single structured data model.

- *Complexity*: It describes how many dimensions a data set has and how it is intertwined and connected. The architecture in the data model has to be modular and flexible in such a manner that scratching around it is not needed afterwards. Parameterization is required for the integration of new requirements, rather than hard coding.

- *Quality*: Data can contain many errors that affect usability. It may be unpredictable, variable, and with too many outliers. This may be inconsistent, such as having gaps and peaks that result from power-downs and connection failures. It may be inaccurate, redundant, or untrustworthy, such as when introduced by human hand. Architectural things should include logs and protection mechanisms that provide the quality of data acquisition and management.

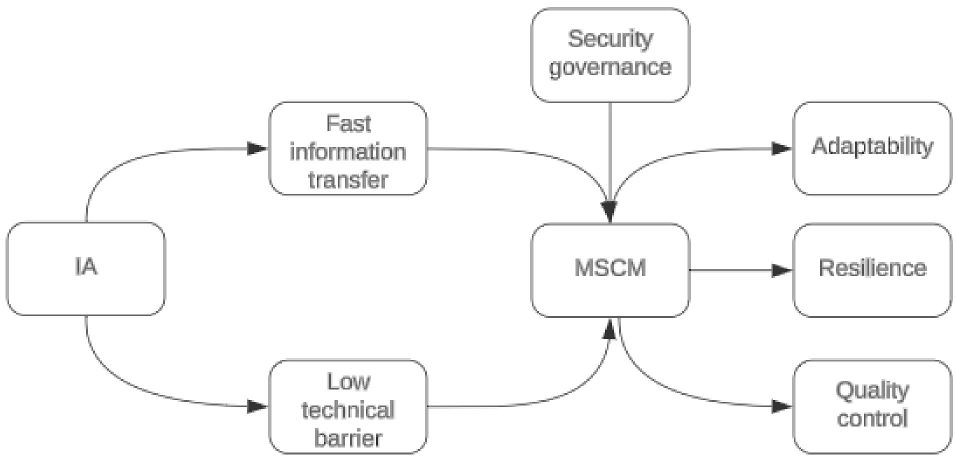
2.5 Conceptual Framework

With all the insights gathered from the theoretical framework, a conceptual framework on the use of IA in a military supply chain is created. This conceptual framework is displayed in Table 3. The framework is constructed out of different categories; each of these categories has factors that have a high impact on the efficiency and/or effectiveness of IA in MSCM. Combining the given factors and the data gathered from the survey and expert interviews, each of these factors can either be verified or debunked. In Figure 7 a compacted illustration is displayed of the conceptual framework.

Category	*Factor*	*Description*	*Reference*
IA	*Cost reduction*	Utilization of automation and AI to decrease operational costs through increased efficiency and reduced human intervention in repetitive tasks.	Syed et al., 2020; Wewerka & Reichert, 2021
	Increased efficiency	Enhancing the speed, quality, and effectiveness of processes through advanced technologies that streamline operations and minimize manual input.	Sutipitakwong & Jamsri, 2020; Lubis & Sembiring, 2023
	Non-invasive technology	Technologies that integrate seamlessly with existing systems without the need for significant modifications or disruptions to current processes.	Siderska, 2020
	Low technical barrier	Automation solutions that are easy to implement and manage, requiring minimal technical skills or complex training.	Sobczak, 2019; Madakam et al., 2019; Dey & Das, 2019
	Fairness	Ensuring unbiased and equitable treatment through the use of technology, typically in the context of algorithms and their decision-making processes.	Ferrara, 2023
	Fast information transfer	Technologies that enable rapid communication and data exchange across various components of the automation system, improving responsiveness and decision-making speed.	Busboom, 2024
Data requirements	*Quantity and quality*	The volume and correctness of data being generated. To provide an sufficient and quality database to be used by the implemented systems. It requires an infrastructure that can be scaled and an efficient data architecture so that high-frequency and large-volume data collections can be handled.	Pradeep et al., 2023; Ngyuen et al, 2010; Biona et al, 2023

MSCM	*Adaptability*	The ability of the military supply chain to adjust methods, operations, and processes effectively to respond to changing circumstances, while still meeting strategic objectives.	Sani et al., 2022; Coito et al., 2017
	Resilience	The capacity of the supply chain to withstand disruptions and quickly recover from them, ensuring continuity and maintaining operational readiness under varying conditions.	Sani et al., 2022; Gürtlich & Lampl, 2022
	Security governance	Refers to the set of policies, procedures, and technologies that manage and protect the systems used within the supply chain from cybersecurity risks.	Sobb and Turnbull, 2020
	Incident response	The organized approach to addressing and managing the aftermath of a security breach or cyberattack, aimed at limiting damage and reducing recovery time and costs.	Chowdhury & Quaddus, 2016
	Quality control	Processes and mechanisms put in place to maintain the standards in production or service delivery, ensuring that all outputs meet the required specifications and are error-free.	Helo and Hao, 2021; Yang et al., 2024

Table 3 Conceptual Framework



Ret

Figure 8 Conceptual Framework

This conceptual model refers to the important factors within a military supply chain and the potential benefits of the correct implementation of IA in such a supply chain. These factors are derived from an analysis of related books, articles, and journals within the theoretical framework. To validate the factors found, a two-part methodology was used, where the factors were validated empirically and mathematically. In this fashion, the importance of the factors found is displayed in the final framework.

3 Methodology

In this section, the methodology that was applied in this thesis will be discussed. In Section 3.1 the focus will be on the data validation and how this data was analysed. The purpose of this gathered data is to validate the important factors found in the conceptual framework. The framework that is applied to validate the results is explained in Section 3.2. A compact conclusion with a detailed figure of the methodology that was used in this thesis will be displayed in Section 3.3.

3.1 Data validation

For this thesis, the data collection parts are divided into two phases. In these two phases, information was gathered regarding the theoretical framework subjects: SCM, RPA, and AI. The data for the first phase was collected using a survey, which constructed answers to the sub-questions. In the second phase, expert interviews were held to verify possible answers drawn from the data collected from the interview. The data for this thesis study is comprised of information gathered from interviews and literature reviews.

3.1.1 Community survey

In this first phase, a survey was sent to people who work at KPMG in the Netherlands, work on a daily basis with RPA or AI, or work in the military supply chain. These questions can be found in Appendix A.2. The survey is constructed out of 19 questions with a mix of open and closed questions. The participants of this survey had some form of expertise in RPA, AI, or SCM, but their level of expertise was not relevant for this part of the research. All participants work at KPMG within the engagement currently ongoing for the Dutch Ministry of Defence (MoD) and are aged between 20 and 65. The decision as to why this selection of people was made and not a broader selection was asked to participate is that a particular knowledge of how a military organisation operates is needed to answer the questions of the survey. All participants currently working at KPMG have or are currently running a project at MoD; therefore, they have the required knowledge to provide a relevant response.

The community survey was sent via email with the consent form as an attachment (Appendix A.1). This survey was created in Microsoft Forms, which made sure all participants who got an email were able to fill out the survey. Retrieving which factors seem to have the most effect, according to the community, was the main focus of the survey. The different benefits, challenges, and concerns were presented to the participants. Analysing these results will give an indication of which factors seem most important in the community of IA and SCM. These factors were then validated again by reviewing these findings in the expert interview to determine if the experts agreed with these findings.

3.1.2 Expert interviews

In the second phase of the research, three expert interviews were done. Due to confidentiality, the transcript of the interviews could not be made public. A general guideline that was maintained during these interviews can be found in Appendix B.1. The experts all have expertise in a topic drawn from the theoretical framework. Specifications surrounding a military organisation were the main topic of all three expert interviews. The experts were asked what they thought would be the biggest challenges or benefits when implementing IA in MSCM.

All expert interviews were constructed in a semi-structured fashion. Since IA is a relatively new technology, a limited amount of research has been done in the field, and even less in relation to the military supply chain. Therefore, in all interviews, the semi-structured approach has been chosen. In this case, the overall topics of the interviews are known, but in each section, there is room for additional questions and, thus, more information.

Due to this fashion, the interviews are more constructed as a discussion rather than a Q&A. The advantages of conducting semi-structured interviews with experts include the ability to engage in detailed discussions, directly verify assumptions, pose specific questions, and explore research gaps. Additionally, these interviews offer the benefit of gaining insights from an outsider who has expertise in the fields of RPA, AI, and SCM and their ethical dilemmas.

All expert interviews were done face-to-face at a KPMG office or online via a Microsoft Teams meeting. The expert interviews were recorded with a smartphone in order to analyse the interviews. The red line in the interview was to follow the experts in order to gain the most information out of the interviews. Additional information was given if they misunderstood certain questions. A guideline used for all 3 interviews can be found in Appendix B.1. With the insights from these expert interviews, the conceptual framework factors were tested against the results gathered from the survey.

3.1.3 Analytic Hierarchy Process (AHP)

To validate the factors found in the theoretical framework with the findings of the survey and expert interviews, the analytic hierarchy process method is applied to the factors. AHP, developed by Thomas Saaty, is a structured technique for organising and analysing complex decisions based on mathematics (Saaty, 1987). The method involves decomposing a decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analysed independently. This decomposition approach helps in dealing with the complexity and multi-faceted nature of decision-making scenarios. The steps of this method are as follows:

1. **Categorize Factors and Extract Grades:**
   Factors found in the theoretical framework are graded based on the survey, and expert interviews are placed in a category. Each factor's importance is determined by the frequency and emphasis placed on it by survey respondents and experts.

2. **Normalise grades:**
   These grades are normalised to make them comparable across factors within each category. Normalization ensures that the scales of measurement are uniform, allowing for a balanced comparison and aggregation of data.

3. **Create Pairwise Matrices**
   Using these normalised grades, pairwise matrices are created for each category. In these matrices, each factor is compared to the other factors present in the category to establish the relative weight of each factor. This comparative approach helps in understanding the relative importance of factors, providing a clear priority structure.

4. **Calculate Priority Vectors**
   Using these normalised grades, priority vectors are constructed for each category, representing the relative weights of each factor. Priority vectors quantify the importance of each factor, making the analysis both rigorous and interpretable.

5. **Combine Priority Vectors**
   Combining the calculated priority vectors gives an average importance ranking of each factor in the different categories. This step synthesises the insights from surveys and expert interviews, providing a comprehensive ranking that reflects both empirical data and expert judgment.

The AHP method was chosen for this study due to several compelling reasons:

- *Structured decision-making*: AHP provides a clear and systematic framework for comparing and prioritising multiple factors, which is crucial in a complex setting like MSCM.

- *Incorporation of expert judgment*: By integrating inputs from experts, AHP enhances the reliability and validity of the decision-making process, ensuring that the outcomes are grounded in practical insights and experience.

- *Handling of both qualitative and quantitative data*: AHP's ability to process both types of data makes it versatile and particularly suited for this research, which involves both survey results and expert interviews.

- *Transparency and consistency*: The method's systematic approach ensures that the decision-making process is transparent and the criteria used are consistent across all evaluations.

Using this method, mathematical validation is applied to conclude the ranking in importance of the factors found. The robustness of the AHP method lies in its ability to handle both qualitative and quantitative data, making it a suitable choice for validating complex decision-making frameworks. A conclusion can be drawn from this ranking regarding the overall importance of the factors according to the survey responses and the expert interviews.

3.2 Framework Adoption

The research will adopt a framework that incorporates elements from both Baxter and Jack (2008) and Houghton et al. (2015). This research follows a well-organized approach to gathering and examining data. It emphasises collecting information from multiple sources and analysing it in stages. This approach, inspired by Baxter and Jack (2008), ensures a thorough examination of the topic and captures the intricacies of the case study. Additionally, Baxter and Jack (2008) found that using a variety of data sources improves the ability to retrieve data from research, which is vital for understanding the subtle dynamics within the use of IA in a military supply chain. IA is a multifaced technology with various applications and implications, much like the complexities in a military supply chain.
By obtaining data from multiple sources, a more comprehensive understanding of the diverse aspects and interactions within this technology can be obtained.

The ability to adapt to the specifics of the case at hand and the importance of navigating the complex interdependencies within technology and the military supply chain are influenced by the principles discussed in Houghton et al. (2015).

This aspect of the framework is particularly important, as it allows the study to respond dynamically to new insights and maintain relevance throughout the research process (Yin,2013). Houghton et al. (2015) contributed to this framework by highlighting the need for ethical considerations, which implicitly require a flexible and adaptive research design to suit various situations and contexts encountered during the study.

Together, this combined framework emphasises the importance of a structured yet flexible approach, aligning with the complex dependencies and rapid evolution characteristic of technology implementation in the military supply chain.

Multi-source data collection methods:

- *Literature Review*
    - Objective: To establish a theoretical foundation on the characteristics, challenges, and benefits of RPA, AI, and SCM.
    - Method: Detailed review of industry reports, conference proceedings, books and academic journals.
    - Scope: The theoretical framework will cover the relevant information that can be found and is needed to construct the conceptual framework.

- *Survey*
    - Objective: To gather valuable empirical information about the general interest, standpoint, and knowledge of RPA, AI, and SCM in the community.
    - Method: An online survey is sent to the participants. This survey is constructed out of open and closed questions.
    - Consent form and questionnaire: In Appendix A.1 the consent form can be found and all questions present in the survey are listed in Appendix A.2

- *Expert interviews*
    - Objective: To collect in-depth qualitative data from industry experts at KPMG and the MoD on the implementation of IA in MSCM.
    - Method: Three semi-structured interviews will be conducted.
    - Opening statement: The experts are asked before the interview to read and agree to the consent form listed in Appendix A.1.

3.3 Research Challenges

This framework integrates a qualitative descriptive framework methodology with a multi-source data collection approach and thematic analysis techniques. Through this approach, the research seeks to contribute valuable insights into the potential implementation of IA in MSCM. The selection of methodologies and frameworks ensures that the research will produce actionable recommendations that are both theoretically grounded and demonstrably applicable in a practical setting. To visualise the methodology and overall structure, figure 8 is created based on the article by Verschuren et al. (2010).

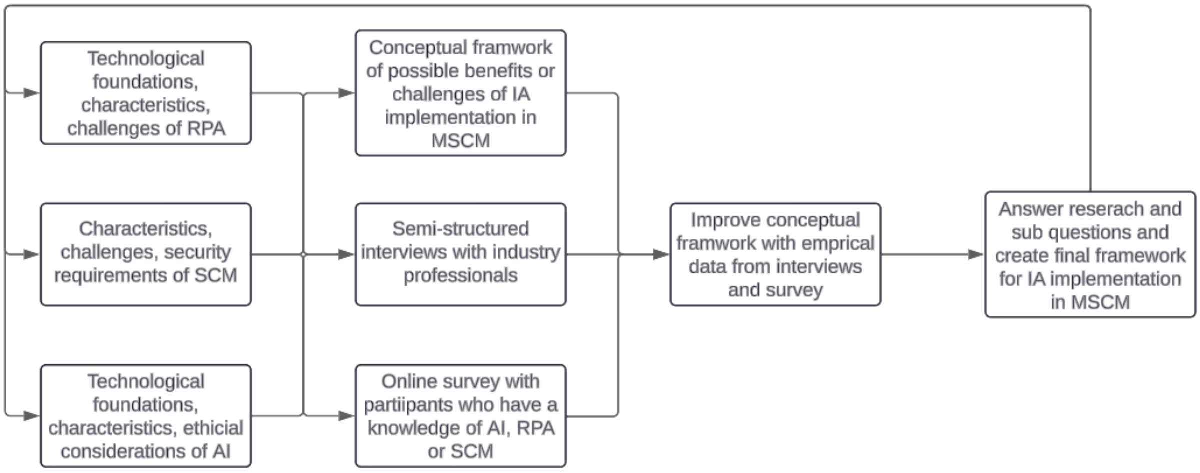


Figure 9 Visualization of thesis structure based on Verschuren et al. (2010)

4 Results

4.1 Conceptual Framework Analysis

The data in this thesis was collected via a survey and three expert interviews. In this section, all data utilized in this thesis and gathered through the collection methods will be displayed. All factors mentioned in the conceptual framework will be analysed with the data collected from the survey and the expert interviews.

The initial data is drawn from the survey in order to see the importance of each factor according to the participants. A validation method is applied by comparing the answers given by the experts in the interview to see if this reflects the input given by the survey participants. These two outcomes will be compared in order to determine the importance of each factor and an additional validation is done via the analytic hierarchy process method.

After determining the importance of each factor a final framework is created containing the key factors drawn from the data collected. A factor might be included in the final framework in an altered fashion if both the survey participants and the experts have advised this with strong substantiation.

The steps taken to gather the intended information from the survey started with cleaning the data by removing every null response. This preparation was needed to facilitate an efficient analysis, especially for handling the responses given in the open-ended questions.

The data collected from the expert interviews and the survey data involved a detailed coding strategy to extract deeper insights.

- *Initial Coding*: Analysing responses to identify initial codes, capturing the essence of the communicated thoughts.
- *Focused Coding*: Refining initial codes into more specific codes that are directly linked to the factors in the conceptual framework.
- *Theme Development*: Grouping related focused codes into themes that accurately reflect the survey responses and expert responses.
- *Linkage to the conceptual framework*: Each theme was directly linked to a specific factor in the conceptual framework. This process was streamlined by the deliberate design of survey and expert questions aimed at obtaining responses easily associated with a particular conceptual factor.

The same methodology for analysing the data was used for the survey and expert data, except for the calculation of the average grade used in the AHP method.

For the survey data:

- *Average grade*: To indicate an importance level of each factor an average grade was determined through the collected data. Each question was related to a factor within the conceptual framework, these questions contained a Linkert scale ranging from 1 to 5 to rate the factor's importance. For the open question the frequency of the related factors was measured, with this data a grade was drawn ranging from 1 to 5. An average score for the Linkert scale and the open questions was calculated in order to calculate the average grade of each factor for each participant. A final mean value was calculated by adding all importance grades given by the participants and dividing this with the amount of participants.

For the expert data:

- *Average grade:* A keyword analysis using a Python Natural Language Processing technique was used to calculate the average grade for the expert data. In this process the transcript of the interviews were pre-processed. A list of keywords related to each factors was created. By counting the frequency of each keyword related to each factor an importance grade is derived. To be able to compare this grade to the average grades gathered from the survey data, the frequencies were normalised and linear scaled to get an average importance grade for each factor of each expert. A final mean value was calculated by adding all importance grades given by the experts and dividing this with the amount of experts.

Concluding these steps makes the survey data and expert data ready to be analysed against each other. Out of these results a final framework is constructed which is displayed in Section 4.3. The relative importance of each factor is also displayed in this final framework and will be calculated by the AHP method.

4.2 Factors Analysis

The factors given in the conceptual framework (section 2.5) are analysed and displayed below. Each factor will have an introduction, survey insights, expert insights, and a conclusion whether or not it will be adopted in the final framework.

4.2.1 Information participants and experts

In this chapter, an overview of the general information of all participants in the survey and expert interviews is given. This is to give a clear view of what the background of the participants is and why certain choices were made.

All participants in the survey were employees of KPMG in the Netherlands and had worked or are working on an engagement at MoD. This is to ensure that the people filling out the survey have an understanding of how a military organisation differs from a cooperative organisation. As KPMG is one of the largest consultancy firms in the Netherlands, it stands to reason that the majority of the responses were filled in by consultants (82%). An additional benefit associated with the profession of the participants is their ability to envision the possibility of a new technology being implemented within an organisation. Since all participants possess intermediate or above technical skills and are familiar with IA, this provides them with a sophisticated ability to envision this implementation.

In order to gain the most possible knowledge out of the data from the survey, personal and job-related questions were asked to construct a knowledge profile for each individual participant. In this survey, a total of 36 responses were gathered; of these responses, 22 were male and 14 were female. 78% of the participants have an age between 25 and 34; this age gap is generally more familiar and comfortable with digital technologies, which helps identify the potential benefits and challenges of IA.

All participants have an existing knowledge of IA, which is needed to envision the technology being used in a military organization. 84% of the participants would rate their technical skills as intermediate or higher as shown in figure 10.

All participants have an existing knowledge of IA, which is needed to envision the technology being used in a military organisation. 84% of the participants would rate their technical skills as intermediate or higher as shown in figure 10.

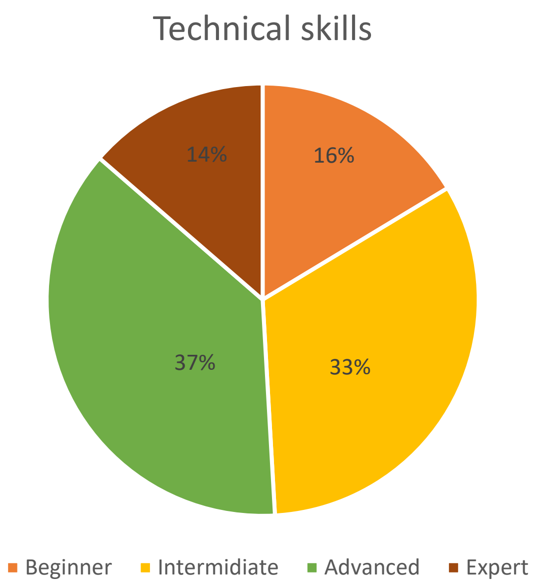


Figure 10 Participants rate of technical skills

As mentioned, three different expert interviews were held with experts of varying expertise. All experts are kept anonymous due to privacy reasons. Below is a small introduction to the experts to give an insight into their expertise and job experience:

- **Expert A:** An associate director at KPMG with over 25 years of experience in the field of digital transformation. Currently working part-time at the Business University Nyenrode as a professor, with 20 years of experience at Delft University in the field of IT outsourcing. With 3 years of experience at MoD in IT platform organisation and management.

- **Expert B:** A senior manager with the Procurement & Supply Chain department at KPMG. The expert has more than 20 years of experience in digital software like SAP and its interaction with supply chain divisions like sourcing & procurement. With additional experience in optimising the supply chain at MoD for the past 2 years.

- **Expert C:** Is a former military officer who is currently working as head of the Robotics Control Centre at the Royal Marechaussee. This function currently focusses on implementing new RPA technologies within the department of the Royal Marechausse.

4.2.2 Adaptability

Adaptability in military supply chains is the capability to effectively change processes, methods, and operations in reaction to changes in the environment, which is often dynamic and unpredictable. This may ensure that a supply chain can adjust to dramatic changes in demand, resource availability, or operation conditions. Adaptability is crucial to maintaining mission readiness and operational effectiveness. It allows for the flexible reallocation of resources, quick reconfiguration of logistical routes, and even the adoption of new technology. It helps to improve the ability of military supply chains to manage the complexities and uncertainties of modern military operations.

Survey response:

In the survey, the question was asked what aspects of MSCM could have the most benefits from the implementation of IA. In the open-ended question stating which factors of MSCM would gain the most impact for IA implementation, 24 out of 36 participants noted that adaptability could see significant improvements. Also, 45% of the participants indicated in the Linkert scale closed question that they strongly agree that IA could enhance the adaptability of MSCM, with only 25% of the participants responding with a medium to low impact. These results show that the participants agree that adaptability is an important factor in MSCM.

Expert response:

All experts agree that adaptability is key to a strong MSCM. Having the ability to quickly adapt to unforeseen situations is paramount in politically tense times, as stated by Expert C. To achieve this adaptability, multiple factors come into play since this is a factor that touches all of the expert's expertise. Expert A stated that it is important when implementing these technologies to make them explainable. This helps in adapting AI systems to the specific needs of military operations. Expert B highlighted the importance of predictive maintenance by integrating various data sources in order to better anticipate and address maintenance needs, thus enhancing overall operational adaptability. Expert C combined two viewpoints by indicating that a robust and adaptable IT infrastructure is important to improve the adaptability of MSCM. Given the unique context and the sheer mass of these organisations, this is not a simple task to do.

Factor:

Based on the answers given by the experts and the survey participants, adaptability is an overarching factor that includes other factors like; quality control, non-invasive technology, data quality, etc. therefore, it stresses the importance of adaptability being adopted into the final framework.

4.2.3 Resilience

In this context, resilience can be seen as the ability to withstand, adjust, and recover from any kind of consequential disruption within the military supply chain: be it from natural disasters, cyberattacks, or geopolitical tensions. It relates to building robust systems that can function even under harsh conditions to maintain operational functionality. Some of the essentials for resilience include redundancy of supply routes, diversification of suppliers, and comprehensive strategies for risk management. By adopting resilience, military supply chains ensure continuity of operations and support for military missions even when faced with unexpected challenges, thus maintaining high operational readiness and effectiveness.

Survey response:

The results of the survey suggest resilience is also an important factor within MSCM. Overall, most of the respondents believe that IA improves the resilience of MSCM to be high to very high (64%) based on the closed Linkert scale question. However, a notable number (24%), are cautious or sceptical about the level of these benefits. This translates to a generally optimistic view of the role of IA in building resilience. Even with some reservations, it should be appropriately managed through cautious implementation and continuous assessment.

Expert response:

Resilience comes down to operational continuity, and all experts agree with the necessity of resilience in MSCM, like adaptability, it is an overarching factor. The same factors apply to resilience as they do to adaptability. It is important to vastly adapt to sudden chances, but with a resilient supply chain, these adaptations might not be necessary. Expert C, who was a former soldier, emphasised the importance of a resilient supply chain. The expert had first-hand experience being in a hostile environment and being relied upon by the products supplied to the forces by the supply chain. Having less process time, whether it is supplying products or analysing data, could significantly improve the overall resilience of the supply chain, according to expert C.

Factor

All responses gathered from the survey and expert interviews indicate the importance of resilience being part of the final framework.

4.2.4 Security governance

The RPA Security Governance frames, guidelines, and technologies are applied to ensure the proper security of technology systems against any kind of cyber threat and vulnerability. It is one of the most critical factors in preserving the integrity and availability of automated processes within the supply chain. Proper access controls, constant monitoring, regular security audits, and proper incident response plans should be included in any good security governance. Security systems will ensure that military supply chains are intact from unauthorised access, data breaches, and other cyber incidents that would compromise highly mission-sensitive operations and information.

Survey response:
The responses show a balanced view of the perspective of introducing IA in military organisations and their perception of the risk to cyber security. The responses were split into three groups, a slight majority of 36% of the respondents did not agree that much risk is associated with this implementation. However, in future questions, it is emphasised that security governance is important; therefore, it needs to be present, but the amount of security risk associated with IA is relatively low. In comparison, 32% advised that IA security governance is an important issue and needs constant attention. The gathered neutral responses could indicate an already sufficient amount of security governance is present for the implementation of IA. The strong opinions polarised within the scales only amplify this critical need to address these concerns for confidence in the implementation of IA.

Expert response:
Security in a military organisation is always necessary due to the handling of sensitive information. In the initial implementation of IA, research has to be done on how to make this technology as secure as possible. The experts agree that these security measures need to be present in the initial implementation, but continuous monitoring of these measures is paramount. A military organisation will always have to deal with unauthorised access and cyber-attacks; therefore, continuous monitoring of the security level is sufficient to deal with these threats and need to be implemented.

Factor
Based on the responses of the participants and the experts, security governance will be implemented in the final framework.

4.2.5 Incident Response

A structured methodology for the interaction and mitigation of the impact of incidents such as security breaches, cyber-attacks, or another kind of event that causes disruption on the supply chain. This entails the development of detailed response protocols, communication plans, and recovery strategies to promptly respond to and resolve incidents. An effective incident response would ensure minimum business disruption and protection of sensitive information while restoring operations as close to the previous state as possible. With a well-done incident response plan, emergencies will be handled, and the mission will continue seamlessly in military supply chains.

Survey response:
80% of the total respondents perceived that IA has a moderate to very high impact on improving the incident response and therefore military readiness. This positive response indicates the potential of IA to significantly improve the efficiency and effectiveness of incident management. The relatively low share of those who doubt it (12%) can be an indication that IA still needs additional validation and communication about its benefits for broader confidence and approval.

Expert response:
Experts A and B both highlight that prompt and effective incident response is essential to minimise disruptions caused by disruptive events. Expert A recommends a structured methodology that includes detailed response protocols. This approach ensures that all stakeholders are prepared and can act swiftly to contain the impact of any incident. Since expert A was the first interviewee, this plan was introduced to experts B and C. Both experts agreed with this course of action to improve incident response. It comes down to continuous monitoring and improvement, according to the experts, which can be achieved by implementing an IA platform that monitors relevant changes in the environment and translates this back to the organisation.
Another point made by Expert C is the importance of training in this incident response. A sophisticated IA platform that helps you prepare for certain situations is very helpful, but especially in combat scenarios, people make a difference. Therefore, sufficient training to not only be operationally ready for combat but also to optimally interact with the integrated IA platform is important in incident response.

Factor
The experts agree that effective incident response is critical for maintaining the security and continuity of MSCM operations. Achieving this involves implementing a structured methodology with pre-arranged response protocols; therefore, incident response is also an important factor to adopt into the final framework.

4.2.6 Quality control

Quality control can be looked upon in two different descriptions: one is the quality control of physical objects such as weapons, ships, and tanks, and the other is the quality control of data. Both are different but could have a big impact on the overall efficiency of the supply chain. By maintaining high levels of quality control, military supply chains can ensure that all components are fit for purpose, thus enhancing operational readiness and mission success

Survey response:

Impacting quality control in MSCM by implementing IA is one of the most important factors, according to the responses. 84% of the participants ensured the reliability of products and services in MSCM could see a significant improvement. This response could be traced back to the engagement of the majority of the participants. The majority work with RPA, which has a significant benefit that has to do with quality control of the administrative processes currently being used in the military organisation. Their own experience with this benefit could play a big part in the responses given. Such a positive perception is critical, as it signals the potential of IA to improve the efficiency and effectiveness of quality control in military settings.

Expert response:

Since expert B has a lot of experience working in a military supply chain, this expert saw the significant potential of this factor in improving the physical quality control of operational equipment. In a military organisation, a lot of equipment is stored in warehouses, where it sits until it is needed. These materials need to be operational at a moment's notice; therefore, frequent quality checks are necessary, but according to expert B, this is a process that requires additional attention. By aiding these quality checks, they can be more frequent and more effective. Learning from these checks by creating a feedback loop was also mentioned by expert B since this creates insights into specific trends and areas that require enhancement.
Expert A stresses the potential when it comes to quality control in data transfer. In high-profile data transfer or modification, which you can expect in a military organisation, data quality is key. Having IA software handle data reduces the potential for human error. Expert C agrees with this viewpoint due to the current positive experience with the improvement of data quality by RPA.

Factor

Both types of quality control are important to adopt into the final framework. As all experts can see, there are excellent implementation possibilities within a military supply chain.

4.2.7 Cost reduction

Cost reduction has everything to do with the multiple ways to reduce the overall cost of the process. IA could be a significant help towards this goal. As mentioned in the theoretical framework, there are numerous ways IA could reduce costs, such as by reducing downtime, improving resource allocation, and reducing error handling. Through the deployment of IA technologies, military organisations can achieve substantial savings by streamlining processes, improving accuracy, and enhancing decision-making capabilities.

Survey response:

Cost reduction was introduced to the participants by asking if they thought IA could increase the speed of operations. The responses gave a clear indication that people are convinced of the ability of IA to increase the speed of operations; 74% indicated a strong to very strong impact. This sped-up of operations is an easy way for MSCM to reduce operational costs. However, 8 participants indicated in the open-ended question 14 that cost reduction could be a challenge. This had to do with the fact of personal experiences regarding the expenses of incorporating new technologies into the IT landscape. They stated that implementing these technologies would not reduce costs in the short-term and that this is not the main concern of a military organisation.

Expert response:

Since all experts have a background in the military or have worked for an engagement in the military, an understanding of how such an organisation thinks is established. Knowing what the Key Performance Indicators (KPIs) are and what a military organisation prioritises are important insights; some factors could differ from a commercial organisation. According to the experts, cost reduction is one of those factors. In the cooperative world, decisions are made based on cost reduction and being competitive in prices, but in a military organisation, this is far less the case since the important factor is operational readiness.

As mentioned by expert A, there is a big difference in philosophy when it comes to trying new business ideas. In a cooperative organisation, these ideas are extensively worked out to see if they are feasible. In a military organisation, these ideas are more often explored in practice to see if they succeed or fail.

Operational readiness is instead far more important than the route you take to achieve this readiness, as also experienced by expert B. Trying to come up with business strategies to implement in the military supply chain, which could potentially reduce the overall cost of the supply chain, seemed like the wrong course of action to improve the supply chain. Cost reduction could be a helpful benefit but is not a main factor when improving MSCM.

Factor

The survey responses indicate that operations can be significantly improved, which results in a cost reduction. Even though this might be the case, according to experts, this is not their main priority within a military organisation. Nevertheless, the cost reduction factor is a large factor in IA so therefor it will be implemented in the final framework.

4.2.8 Increased efficiency

Increased efficiency with the implementation of IA has the potential to reduce process times and improve overall productivity. This increase in productivity can be related to multiple factors that IA can aid in: better resource utilisation, improved decision-making, or faster response time. Leveraging this technology, supply chains can achieve higher levels of operational performance, making sure that military personnel receive the support and materials they need promptly and reliably.

Survey response:

Each participant in the survey has worked with RPA at a military organisation or is really closely associated with this technology. Also, all participants have an understanding of IA and its increased potential compared to RPA. Currently, the use of RPA at MoD demonstrates the potential for increased efficiency at multiple levels. Therefore, it is no surprise that 75% of the participants believe that addressing inefficiencies significantly impacts the overall effectiveness of the military supply chain.

Expert response:

The main cause of the inefficiency within a military organisation is the fragmented IT systems, according to expert C. Different systems that do not communicate effectively with each other can cause delays and errors in data transfer. This fragmentation often requires manual intervention to bridge the gaps between the systems. The potential, especially with the non-invasive nature of IA, is significant, according to expert C. The expert also stated that utilising integrated platforms can facilitate real-time monitoring and management of supply chain activities.

Both experts A and B agreed with this viewpoint but also saw the potential in streamlining processes and implementing automation to reduce manual interventions and thus improve efficiency. One of the main characteristics of RPA is taking over repetitive tasks from employees in order to free up their time to participate in more cognitively demanding activities. IA, since it can incorporate RPA, has this same characteristic. This could also be a significant improvement in efficiency since job shortages in the armed forces are a worldwide problem (Geluk, et al., 2024).

Factor

With the numerous potentials listed by the experts and participants, increased efficiency needs to be adopted into the final framework.

4.2.9 Non-invasive technology

Non-invasive technology refers to solutions that integrate seamlessly with existing systems without requiring significant modifications within the existing IT landscape. This factor is important to ensure easy implementation and minimise the resistance of new technologies within the supply chain. By adopting non-invasive technologies like IA, a military organisation can improve their capabilities while avoiding the costs and complexities associated with major IT landscape changes.

Survey response:

One of the biggest challenges given by the participants when implementing IA was the current IT landscape within military organisations. 41% of the responses indicated that the current IT landscape is not sufficient for the implementation of IA. This indicates that significant changes need to be made when implementing new technologies, and it also stresses the importance of non-invasive technology. IA is a broad concept and can be implemented in various ways. Multiple of these implementations require little to no change in the current IT landscape. Therefore, 78% of the participants agree that non-invasive technology is an important factor of IA in the implementation of a military supply chain.

Expert response:

Minimal disruption and ease of integration were the key points given by the experts. A key aspect of a military organisation is being operational at all times; therefore, implementing non-invasive technology to improve efficiency could be significant, according to expert A. Non-invasive technologies also have the benefit that they interact with existing programmes within the IT landscape, which implies employees will also remain using the same programmes. This can reduce the amount of time and money spent on training employees.

A key point made by experts A and C was that IA can enhance data utilisation between different software platforms in the short term. Upgrading a complete IT landscape to have access to various data sources takes a significant amount of time and money. When implementing IA with AI capabilities, this can enable better analysis, forecasting, and decision-making based on accurate data from different software programmes.

Factor

Due to the nature of a divided IT landscape in military organisations and the need for improved data utilisation between software programmes, non-invasive technology is important to be adopted into the final framework.

4.2.10 Low technical barrier

Low technical barriers state that automation solutions should be implementable and manageable without much application of technical skills or involving complex training. This ensures the theory described above, where new technologies should be picked up by a wide range of adopters quickly and effectively. In this regard, low technical barriers become particularly important for military supply chains, which benefit from rapid deployment and ease of use. Military organisations can make their operational capability better by selecting low-tech barrier solutions without the need to take up expensive and time-consuming training.

Survey response:

A topic frequently mentioned in the survey was the education and convincing of people to use IA in MSCM. A low technical barrier is an important factor in IA since it reduces the amount of education that is needed in order to get employees to understand the technology. Convincing people to use new technology seems like a hard task, according to the participants. Making it as easy as possible with a low technical barrier reduces the steps people have to take in order to adopt this new technology. "Getting the people to participate into adopting new IA technologies", this quote and 6 responses coded in the same category were retrieved from question 14. This indicates that the factor low technical barrier is seen as a big challenge.

Expert response:

Explained by expert A, the level of technical expertise within a military organisation varies significantly, especially in the lower section of the supply chain, where this expertise may be very low. Having a low technical barrier when implementing any new form of technology is important, especially in a military organisation. All experts also indicated the amount of time and money spent on the training of the right personnel for certain processes. Military organisations are known for their large size; adopting a new technology like IA is a significant operation and needs to be as easy as possible. Having a low technical barrier within this technology increases the chances of a smooth integration.

Factor

In the survey, it was flagged as an important factor; this was also the case in the expert interviews. Therefore, the factor technical barrier will be implemented into the final framework.

4.2.11 Fairness

Fairness in technology implementation refers to ensuring unbiased treatment when using technology models. This is crucial to ethical issues and trust with AI and automation algorithms. Fairness ensures the removal of potential bias in algorithms, transparency in decision-making, and equal opportunities for all users. By doing what is deemed fair, military supply chains can create an environment of integrity and accountability in which stakeholder trust and confidence can be maintained and created.

Survey response:

The participants indicate that implementing IA may increase the possibilities for additional risks, such as cyber-attacks, data leaks, and cyber-espionage. This doesn't take away the fact that 95% of the participants believed that the potential for additional security risks did not outweigh the potential efficiency gained from IA implementation. This does not take away the fact that extra security measures, such as an increase in fairness, needs to be applied. What strongly came out of the survey results was the use of strict regulations when deploying AI and IA technologies. 91% of the participants strongly agreed that a military organisation should prioritise transparent AI, and 91% agreed that there should be strict regulations governing the use of IA to protect privacy and data integrity.

Expert response:

Expert A mentioned that a new discussion is forming regarding fairness in AI. The more common use of generative AI is growing, which has people divided. When it comes to fairness in AI, the ideal scenario is that every step or decision of an algorithm can be explained. With the use of generative AI, or non-explainable AI, this important factor is no longer possible. Therefore, expert A insisted on using this factor to make the IA implementation fair and therefore explainable to reduce the chance for exclusion or non-explainable decisions. Also, the ability to learn from such algorithms increases when every decision is explained, which can cause a change in people's behaviour to address certain situations.

In a military context, data is sensitive and needs to be handled with care. Expert B pointed out that continuous monitoring of these algorithms is paramount. These audits should assess the performance of IA systems in terms of identifying any biases or unfair practises. Continuous monitoring helps in vastly addressing any issues that arise, ensuring ongoing fairness in decision-making processes.

Factor

Going off of the responses from the survey and the answers given by the experts, fairness in IA implementation is extremely important. Especially with the nature of the data used in a military organisation. Therefore, fairness is also adopted into the final framework.

4.2.12 Fast information transfer

Being able to communicate between multiple systems within an IT landscape is important to increase efficiency. Having sufficient information at all points within an organisation helps by not only having details on what is going on in every department, but it also enables systems to gain insight into systems outside of their scope. Fast information transfer can improve coordination, reduce response times, and enhance the overall effectiveness of supply chain operations. By using frameworks like ISA-95, the ability of systems to connect with each other increases significantly.

Survey response:
A reoccurring topic in the survey responses was that a military organisation is widely scattered. This means different systems may not have the necessary information at certain points. Therefore, this factor of IA's ability to connect different systems without making significant changes to the IT infrastructure was positively received. 82% of the participants agree that fast information transfer can impact the MSCM and is needed in a military organisation.

Expert response:
As mentioned in the theoretical framework, the ISA-95 standards facilitate fast and efficient information transfer. Due to the expertise of expert A, a question was formulated to see if such standards would hold up in a military organisation. Expert A believed these implementations could make a significant improvement in information transfer. Since not only the systems are scattered but also some different departments adhere to different standards,. Since ISA-95 is also an international standard, this could be very promising, according to expert A, not only for national use but also for international use.
Expert B highlighted the importance of real-time data transfer to improve efficiency in MSCM. Integrating real-time data from various sources allows for immediate access to relevant information. Due to the additional automation being added in the MSCM, the data transfer between systems is potentially faster, but it also requires less manual labour, which will also increase the efficiency of a military supply chain. Expert C agreed with the statement made by Expert B, with the additional significance mentioned regarding the importance of real-time data in the field.

Factor
All the experts gave a clear opinion on the factor of fast information transfer, and since all agreed on the importance of this factor, it will be implemented into the final framework.

4.2.13 Data quantity and quality

Data quality and quantity refer to the accuracy, size, and completeness of the data being used in the supply chain. High-quality and large sets of data are essential for effective decision-making. Since IA algorithms have the potential to learn from themselves, the data on which they are trained needs to be sufficient. Here also comes the factor of fairness into play, because this impacts the correctness of the dataset—the lack of bias, for instance. By maintaining high standards of data quality, military supply chains can improve their analytical capabilities, support strategic planning, and enhance overall mission effectiveness.

Survey response:

In the survey, the participants were asked what their primary concerns were regarding the use of IA in MSCM. 32% of the participants included the keyword "data" in their answers. The answers ranged from the lack of sufficient data sources to the overall quality of the data. This indicated that significant improvements can be made in this domain.

Expert response:

Since MSCM is being used in a variety of settings, it is important for technologies to have the best possible information when making decisions. According to expert A, a broad and qualitative data set ensures that IA systems can account for a wide range of scenarios and variables. This will also aid in the overall adaptability and resilience of the MSCM within the organisation.

Expert B mentioned the importance of regulatory data quality checks to ensure that the data used in IA systems is accurate and reliable. This is closely related to the quality control factor, which was discussed previously.

Factor

According to the participants of the survey, significant improvements can be made in the domain of data quantity and quality; this was validated by the experts. After careful analysis of the coded survey responses and the transcribed expert interview, the conclusion was made that an insufficient amount of data was retrieved to measure the importance of this factor. That is why the decision was made to not include this factor in the final framework and, therefore, not include it in the AHP method.

4.2.14 Organisational change management

Implementing IA within a military organisation presents challenges due to the resistance to change. Organisational change management is a critical factor that addresses these challenges by facilitating the smooth adoption of IA technologies. This factor emphasises managing the fears and hesitations associated with new technology integration, particularly in a secure and structured environment like the military. Effective change management involves strategic planning with transparent communication; therefore, employees will be ensured that the transition to IA is seamless and widely accepted. By addressing resistance to change and creating a supportive environment, organisational change management plays a crucial role in the successful implementation of IA (Barbaroux, 2011).

Survey response:
This factor was originally not present in the conceptual framework displayed in Section 2.5. After analysing the survey results, a significant number of responses to the open questions were related to the people side of the organisation. 43% of the participants mentioned that one of the main challenges is convincing the employees to use these new technologies. Convincing them to see that a technology such as IA is there to aid them in their daily tasks and not to take over requires a strategic and detailed plan. This has to be done in every department within a military organisation, which will make it a large undertaking. The participants of the survey acknowledged the fact that technologies such as IA are implemented from the ground up. The employees have to work with these technologies, which makes a satisfied employee who understands their task that much more important.

Expert response:
Since all experts have experience working within a military organisation, they know the types of employees who work in such environments. At some point in the interviews, all the experts gave the suggestion that convincing employees is also a main factor in implementing new technologies. Expert C noted that people are used to their jobs being a certain way and are sometimes not pleased with outside help. According to the expert, this has to do with the close bond between military employees. Therefore, if outside help is required to implement new technologies, a detailed approach on how to tackle this issue is needed.

Factor:
After analysing the responses from the survey and the expert interviews, this factor was mentioned too often to not be implemented into the final framework. Even though this particular factor was not mentioned in the theoretical framework, it has a lot of connection points with other factors. This is the reason why it could still be implemented into the final framework. This factor will not be used in the AHP method since not enough quantitative data was gathered from the survey.

After this analysis, each of the individual factors is empirically validated by analysing the survey and expert data. To not only empirically validate these factors, the method; Analytic Hierarchy Process is applied to also validate these factors mathematically. Each factor deemed important by the participants of the survey and the experts will be analysed by the AHP method and adopted into the final framework.

4.3 Analytic Hierarchy Process

4.3.1 Analytic Hierarchy Process (AHP)

To further analyse the data collected from the survey responses and the expert interviews, the method Analytic Hierarchy Process (AHP) is implemented. This structured approach ensures that recommendations are both theoretically sound and empirically validated.

The AHP method was introduced by Thomas Saaty, this method is a systematic procedure for hierarchical decision-making that translates pairwise comparison judgements into priorities (Saaty, 1987). The objective is to systematically assess the relative importance of the factors identified through surveys and expert interviews. This structured approach ensures a balanced consideration of different perspectives, leading to more informed and effective decision-making. This method consists of several steps:

1. **Categorized Factors and Grades:**
   The first step of the AHP method is to organise the factors according to the conceptual framework outlined in this thesis in Chapter 2.5. Extract the grades for how often each factor was mentioned in the survey and how important they deemed this specific factor. For the expert interview, an analysis was done on the coded transcript, and an average grade was assigned to each factor for each specific expert. The factor Data quantity and quality and organisational change management were not implemented into the AHP method since not enough data was collected from the survey and expert interviews.

2. **Normalise Grades :**
   Normalise the extracted grades to make them comparable across factors within each category. This normalisation process is essential to balance the different scales and ensure that each factor is weighted appropriately. For factors where the grade is marked as "-", indicating that the factor was not sufficient enough to be included, it will be excluded from the normalisation process to avoid skewing the results.

3. **Pairwise Comparison Matrices** :
   Using the normalised grades, develop pairwise comparison matrices for each category. This step involves comparing each factor against others within the same category to determine their relative importance. Pairwise comparisons facilitate a deeper understanding of how factors rank relative to each other.

4. **Priority Vectors**:
   Normalise the pairwise comparison matrices and calculate the priority vectors for each category. These vectors represent the relative weights of each factor based on the comparisons. This step translates the qualitative assessments into quantitative measures, providing a clear representation of the importance of each factor.

5. **Combine Priority Vectors**:
   Finally, integrate the rankings from the survey and experts to form an overall prioritised framework. This combined ranking offers a comprehensive view that considers both empirical data and expert opinions.

4.3.2 Categorized Factors and Grades

Each of the factors are divided into two categories. This categorization helps in organising the factors for further analysis. In Table 4 all the factors are displayed with a corresponding importance grade. These grades are calculated based on the coding analysis performed on the survey data and the expert interviews. Each individual survey response is analysed, and an importance grade is assigned for each factor. An average is calculated based on all the analysed survey responses. This methodology is also applied to analyse the expert interviews.

Category	**Factor**	**Survey**	**Experts**
IA	*Cost reduction*	2.15	3
	Increased efficiency	2.95	4
	Non-invasive technology	3.3	3
	Low technical barrier	3.1	3.5
	Fairness	3.89	4
	Fast information transfer	3.5	4
	Data quantity and quality	-	-
MSCM	*Adaptability*	3.04	4
	Resilience	1.96	3.67
	Security governance	3.56	4.33
	Wor	1.96	4
	Quality control	3.7	3.33

Table 4 Factors and Grades

After carefully analysing the survey and expert interview data, not enough sufficient data was collected for the factors of quality and quantity. Therefore, this factor will be excluded from the calculations. Further research has to be done in order to review the importance of this factor.

4.3.3 Normalised Grades

Normalisation is done to ensure that different scales of grades do not affect the analysis of the data. To normalise this data, the sum of the scores for each factor was taken and divided by the total sum. In Table 5 for each factor, the normalised grades are displayed for the survey and expert data.

Category	**Factor**	**Survey**	**Experts**
IA	*Cost Reduction*	0.1138	0.1395
	Increased Efficiency	0.1562	0.1860
	Non-invasive Technology	0.1747	0.1395
	Low Technical Barrier	0.1641	0.1628
	Fairness	0.2059	0.1860
	Fast Information Transfer	0.1853	0.1860
MSCM	*Adaptability*	0.2138	0.2069
	Resilience	0.1378	0.1899
	Security Governance	0.2504	0.2240
	Incident Response	0.1378	0.2069
	Quality Control	0.2602	0.1723

Table 5 Normalised Factors

4.3.4 Pairwise Comparison Matrices

The normalised grades displayed in Table 5 were then used to construct pairwise comparison matrices. These matrices compare each factor against others within the same category to determine their relative importance. The factors are split up into two categories (MSCM and IA), a total of 4 tables were constructed.

To calculate the pairwise comparison matrices, the following formula is used:

$$X_{ij} = \frac{G_i}{G_j}$$

- G_i is the normalised grade for factor i
- G_j is the normalised grade for factor j
- X_{ij} is the pairwise comparison value at row i and column j

The primary purpose of these matrices is to facilitate a systematic and quantitative comparison of the various factors identified in the study. By using pairwise comparisons, each factor is evaluated against every other factor in terms of their relative importance concerning a specific factor. In decision-making scenarios involving multiple criteria, pairwise comparisons provide a clear framework for evaluating the trade-offs between different factors. By converting qualitative assessments into quantitative values, pairwise comparison matrices enable the integration of expert opinions in a structured manner. This quantification is essential for deriving priority vectors, which represent the relative weights of the factors.

Pairwise Comparison Matrix (MSCM):

Factor	Adaptability	Resilience	Security governance	Incident response	Quality control
Adaptability	1	1.5519	0.8540	1.5519	0.8215
Resilience	0.6443	1	0.5505	1	0.5289
Security Governance	1.1712	1.8166	1	1.8166	0.9601
Incident Response	0.6443	1	0.5505	1	0.5289
Quality Control	1.2174	1.8914	1.0416	1.8914	1

Table 6 Pairwise Comparison Matrix (MSCM) Survey

Factor	Adaptability	Resilience	Security governance	Incident response	Quality control
Adaptability	1	1.0907	0.9233	1	1.2009
Resilience	0.9168	1	0.8256	0.9168	1.0993
Security Governance	1.0831	1.2114	1	1.2114	1.2961
Incident Response	1	1.0907	0.8256	1	1.2009
Quality Control	0.8328	0.9093	0.7715	0.8328	1

Table 7 Pairwise Comparison Matrix (MSCM) Experts

Pairwise Comparison Matrix (IA):

Factor	Cost reduction	Increased efficiency	Non-invasive technology	Low technical barrier	Fairness	Fast information transfer
Cost Reduction	1	0.7285	0.6513	0.6933	0.5529	0.6143
Increased Efficiency	1.3733	1	0.8934	0.9183	0.7600	0.8438
Non-invasive Technology	1.5357	1.1195	1	1.0593	0.8500	0.9265
Low Technical Barrier	1.4425	1.089	0.9440	1	0.8024	0.8821
Fairness	1.8092	1.3158	1.1764	1.2462	1	1.087
Fast Information Transfer	1.64	1.20	1.08	1.14	0.90	1.00

Table 8 Pairwise Comparison Matrix (IA) Survey

Factor	Cost reduction	Increased efficiency	Non-invasive technology	Low technical barrier	Fairness	Fast information transfer
Cost Reduction	1	0.75	1	0.8571	0.75	0.75
Increased Efficiency	1.3333	1	1.3333	1.1429	1	1
Non-invasive Technology	1	0.75	1	0.8571	0.75	0.75
Low Technical Barrier	1.1667	0.875	1.1667	1	0.875	0.875
Fairness	1.3333	1	1.3333	1.1429	1	1
Fast Information Transfer	1.3333	1	1.3333	1.1429	1	1

Table 9 Pairwise Comparison Matrix (IA) Experts

4.3.5 Priority Vectors

Normalising the pairwise comparison matrices results in priority vectors, which represent the relative weights of each factor based on the comparisons. To derive the priority vector, the normalised values in each row are averaged, producing a vector that indicates the relative importance of each factor. This priority vector ensures that the individual factor's weight is consistent with the overall judgments, allowing for a clear and quantifiable prioritisation.

Normalised Pair Comparison Matrices (MSCM)

Factor	Adaptability	Resilience	Security governance	Incident response	Quality control
Adaptability	0.2138	0.2138	0.2138	0.2138	0.2138
Resilience	0.1378	0.1378	0.1378	0.1378	0.1378
Security Governance	0.2504	0.2504	0.2504	0.2504	0.2504
Incident Response	0.1378	0.1378	0.1378	0.1378	0.1378
Quality Control	0.2602	0.2602	0.2602	0.2602	0.2602

Table 10 Normalised Pairwise Comparison Matrix (MSCM) Survey

Factor	Adaptability	Resilience	Security governance	Incident response	Quality control
Adaptability	0.2069	0.2069	0.2069	0.2069	0.2069
Resilience	0.1899	0.1899	0.1899	0.1899	0.1899
Security Governance	0.2240	0.2240	0.2240	0.2240	0.2240
Incident Response	0.2069	0.2069	0.2069	0.2069	0.2069
Quality Control	0.1723	0.1723	0.1723	0.1723	0.1723

Table 11 Normalised Pairwise Comparison Matrix (MSCM) Experts

Priority Vector (MSCM)

Factor	Priority Vector
Adaptability	0.2138
Resilience	0.1378
Security Governance	0.2504
Incident Response	0.1378
Quality Control	0.2602

Table 12 Priority vector (MSCM) Survey

Factor	Priority Vector
Adaptability	0.2069
Resilience	0.1899
Security Governance	0.2240
Incident Response	0.2069
Quality Control	0.1723

Table 13 Priority vector (MSCM) Experts

Normalised Pair Comparison Matrices (IA)

Factor	Cost reduction	Increased efficiency	Non-invasive technology	Low technical barrier	Fairness	Fast information transfer
Cost Reduction	0.1138	0.1131	0.1134	0.1146	0.1132	0.1147
Increased Efficiency	0.1562	0.1554	0.1555	0.1517	0.1556	0.1576
Non-invasive Technology	0.1747	0.1738	0.1741	0.1749	0.1743	0.1738
Low Technical Barrier	0.1641	0.1691	0.1644	0.1652	0.1642	0.1648
Fairness	0.2059	0.2043	0.2048	0.2059	0.2047	0.2032
Fast Information Transfer	0.1853	0.1842	0.1878	0.1877	0.1830	0.1866

Table 14 Normalised Pairwise Comparison Matrix (IA) Survey

Factor	Cost reduction	Increased efficiency	Non-invasive technology	Low technical barrier	Fairness	Fast information transfer
Cost Reduction	0.1395	0.1395	0.1395	0.1395	0.1395	0.1395
Increased Efficiency	0.1860	0.1860	0.1860	0.1860	0.1860	0.1860
Non-invasive Technology	0.1395	0.1395	0.1395	0.1395	0.1395	0.1395
Low Technical Barrier	0.1628	0.1628	0.1628	0.1628	0.1628	0.1628
Fairness	0.1860	0.1860	0.1860	0.1860	0.1860	0.1860
Fast Information Transfer	0.1860	0.1860	0.1860	0.1860	0.1860	0.1860

Table 15 Normalised Pairwise Comparison Matrix (IA) Experts

Priority Vector (IA)

Factor	Survey Priority Vector
Cost Reduction	0.1139
Increased Efficiency	0.1554
Non-invasive Technology	0.1744
Low Technical Barrier	0.1654
Fairness	0.2049
Fast Information Transfer	0.1858

Table 16 Priority vector (IA) survey

Factor	Expert Priority Vector
Cost Reduction	0.1395
Increased Efficiency	0.1860
Non-invasive Technology	0.1395
Low Technical Barrier	0.1628
Fairness	0.1860
Fast Information Transfer	0.1860

Table 17 Priority vector (IA) Experts

Once the priority vectors are calculated, they provide a ranking of the factors based on their relative weights. This ranking helps in identifying which factors are most significant in the decision-making process. This step ensures that all relevant factors are appropriately weighted and ranked, providing a solid foundation for effective and informed decision-making

4.3.6 Combine Priority Vectors

The final step is to combine the priority vectors of the survey data and the expert data. To calculate this combined vector, an even weight is assigned to each priority vector. The combined priority vectors are calculated using the average of the normalised grades for each factor.

Category	Factor	Combined priority vector
IA	*Fairness*	0.1955
	Fast Information Transfer	0.1859
	Increased Efficiency	0.1707
	Low Technical Barrier	0.1641
	Non-invasive Technology	0.1570
	Cost Reduction	0.1267
MSCM	*Security Governance*	0.2372
	Quality Control	0.2163
	Adaptability	0.2104
	Incident Response	0.1724
	Resilience	0.1639

Table 18 Most Important Factors per category

4.4 Final framework

The importance of all factors in the conceptual framework was researched with the data collected from the participants in the survey. After the validation was done through the expert interviews, a final framework was created, which is displayed in Table 5.

Category	*Factor*	*Description*	*Priority Vector*
IA	Cost reduction	Utilization of automation and AI to decrease operational costs through increased efficiency and reduced human intervention in repetitive tasks.	0.1267
	Increased efficiency	Enhancing the speed, quality, and effectiveness of processes through advanced technologies that streamline operations and minimize manual input.	0.1707
	Non-invasive technology	Technologies that integrate seamlessly with existing systems without the need for significant modifications or disruptions to current processes.	0.1570
	Low technical barrier	Automation solutions that are easy to implement and manage, requiring minimal technical skills or complex training.	0.1641
	Fairness	Ensuring unbiased and equitable treatment through the use of technology, typically in the context of algorithms and their decision-making processes.	0.1955
	Fast information transfer	Technologies that enable rapid communication and data exchange across various components of the automation system, improving responsiveness and decision-making speed.	0.1859
MSCM	*Adaptability*	The ability of the military supply chain to adjust methods, operations, and processes effectively to respond to changing circumstances, while still meeting strategic objectives.	0.2104
	Resilience	The capacity of the supply chain to withstand disruptions and quickly recover from them, ensuring continuity and maintaining operational readiness under varying conditions.	0.1639
	Security governance	Refers to the set of policies, procedures, and technologies that manage and protect the systems used within the supply chain from cybersecurity risks.	0.2372
	Incident response	The organized approach to addressing and managing the aftermath of a security breach or cyberattack, aimed at limiting damage and reducing recovery time and costs.	0.1724
	Quality control	Processes and mechanisms put in place to maintain the standards in production or service delivery, ensuring that all outputs meet the required specifications and are error-free.	0.2163

Table 5; Final framework

In this final framework, the factors found in the theoretical framework that are deemed important according to the empirical data are displayed. The factors are divided into two categories: IA and MSCM. With the implementation of IA, significant improvements can be made in certain factors of the military supply chain. These factors are displayed in the final framework, under the category MSCM, with the corresponding priority vector, which displays the potential for significant improvement inside the supply chain.

The factors displayed in the IA category are key points in the overshadowing technology called IA. The priority vector represents the importance and effectiveness of improving a military supply chain.

5 Discussion and limitations

5.1 Main findings

With all the data collected from the survey and expert interviews, this section provides an overview of the main findings from this research. The findings are organised in a structured manner to highlight the main findings derived from this study. Below are bullet points summarising the main results, followed by a detailed explanation of each point.

- According to the AHP method, fairness and security governance are the most important factors when it comes to implementing IA.

- The role of fairness and transparency is crucial to the successful implementation of IA in MSCM.

- All participants and experts had a positive attitude towards the adoption of Intelligent IA in MSCM.

- The primary benefits of IA implementation include increased efficiency and improved accuracy.

- The primary challenges identified include data security concerns and the potential resistance to change from employees.

- In a military organisation, being prepared for unpredictable events is an important factor; how this is achieved is less important. This means that factors such as cost reduction are not a main focus within a military organisation, unlike a typical commercial organisation.

Talking about fairness in IA, trust in IA systems, and transparency within the algorithms emerged as critical factors for a successful implementation. Participants emphasised the need for clear communications about how IA systems work, their benefits, and any potential additional risks. Having to deal with sensitive information makes it that much more important to create fairness in the algorithms. Due to this fairness, the algorithms become explainable, which means that every decision made can be traced back to see what data this decision is based on. This is paramount when making decisions in hostile environments or performing data analytics on classified information. Creating this fairness in IA is therefore an important factor in increasing the possibility of military employees accepting this technology. Given the findings in the AHP method, fairness has a priority vector of 0.1979 and security governance has a priority vector of 0.2408. These factors are deemed most important by the respondents and expert interviews.

The first and arguably the most important finding is the positive attitude towards the potential implementation of IA in MSCM. All the participants and experts recognised the potential for IA to revolutionise supply chain processes by automating routine tasks and allowing employees to focus on more high-value activities (Boudreau et al., 2015). This positive attitude is essential for driving the initial stages of IA implementation. This positive attitude is essential for the initial implementation, as are certain characteristics of IA and RPA. Two important characteristics of these technologies are that these technologies could be implemented non-invasively (priority vector: 0.1570) and that there is a low technical barrier (0.1641) to learning the basic concepts. The survey responses highlighted that convincing people to use new technologies can be challenging, but having a low technical barrier is crucial as it reduces the amount of education needed for employees to understand the technology. As indicated by expert A, the variation in levels of technical expertise within military organisations, especially in the lower sections of the supply chain, makes this low technical barrier essential for an initial IA implementation. With multiple characteristics being mentioned in the theoretical framework, these came back as the most important following the results

As the participants saw the potential of an IA implementation in MSCM, certain main benefits came to light. One of these benefits was the potential increased efficiency and improved accuracy (0.1707) of the supply chain processes. IA can streamline operations by reducing manual input and processing times, leading to faster and more effective workflows. The use of RPA at the MoD demonstrates the potential for increased efficiency at multiple levels of the supply chain. Automation of these processes not only increases efficiency but also increases accuracy since less human interaction is required regarding the data. Experts noted that IA can enhance data utilisation between different software platforms, which can enable better data handling from various sources. These benefits correspond with the benefits found in the theoretical framework.

Implementing a new technology within a large organisation is never easy and comes with its own challenges. A military organisation is usually described as a slow and old organisation, which was also verified by the survey participants. Having experience implementing a new technology in such an organisation gave them an inside look at some of the challenges that might come up. One of these challenges is the overall resistance to change. One side of this challenge is that IA is a relatively new technology, which can make people hesitant to use it in a secure environment such as the military. Another side is that people may fear job displacement or the struggle to adapt to new technologies. The core characteristics of IA are its low technical barrier and its design to help people with their daily activities rather than taking over. These characteristics imply that these technologies are not made to displace workers but to aid them in their tasks. Nevertheless, people need to be made aware of these characteristics before they can trust the implementation of this technology. Here comes a well-spoken subject within the survey and interviews to light, which is to make the process as transparent and fair as possible. In this case, employees are able to follow the entire process, which also increases their overall knowledge regarding IA.

Every supply chain, whether it is military or commercial, would like to be adaptive (0.2104) and resistant (0.1639) to unexpected scenarios. The reason for this train of thought is different in these supply chains. A commercial supply chain has as its main focus “making a profit”, whereas a military supply chain has as its main focus “being prepared”.
Disruptions within the military supply chain can have life-or-death consequences for those deployed into hostile environments. Therefore, their main priority is getting supplies, information, or people to the location where they are needed. Cost reduction could be an additional benefit to have within a military supply chain, but the main benefit would be the increase in adaptability and resilience of the supply chain. This is also reflected by the low priority vector of cost reduction (0.1267).

5.2 Limitations

Despite the comprehensive approach, this study faced several limitations:

- **Sample size:** This research was limited to 36 participants in the survey and 3 expert interviews. Despite this being a sufficient amount of data for this research, it limits the potential for more relevant data given by additional people.

- **Employment diversity:** The original idea was to get an inside look at both the perspective of external employees of a military organisation and internal employees. Due to confidentiality regulations, the survey could not be sent to internal employees at MoD. Therefore, only employees of KPMG are asked to fill out the survey, which can result in a one-sided view of the data results.

- **Case Study Scope:** This research investigates the factors within a military context. The information gathered from the survey and expert interviews is based on the Dutch MoD. Despite the initial information gathered in the theoretical framework being based on the global factors of a military organisation, the final results are based solely on internal and external employees of the MoD. This can cause the conclusions drawn from the results to differ in other countries.

- **Dynamic Environment:** Due to the fast growth of the use of automation, the environment of IA is rapidly evolving. This causes some examples, given the implementation of IA to become outdated. Continuous updates regarding the implementation of IA are needed to keep up with technological advancements.

- **Confidentiality:** As mentioned, due to confidentiality regarding the security regulations at MoD, the survey could not be sent to employees of MoD. Also, due to confidentiality, the transcripts of the expert interviews and the specific answers given in the survey could not be made public. Since the data could be collected and used for this research, this issue did not affect this study. It could, however, restrict any future research based on this paper, which requires additional information regarding the collected data.

- **Limited expert interview:** Another limitations of this thesis is the amount of conducted expert interviews. While the AHP relies heavily on expert judgments to establish the relative importance of various factors, the small sample size of experts may introduce bias and limit the generalisability of the findings. The limited number of interviews can result in a narrower range of perspectives and potentially overlook diverse insights that could have been captured with a larger pool of experts. This limitation is particularly relevant in the context of military supply chain management, where the complexity and variability of scenarios require a broad spectrum of expert opinions. Therefore, future research should aim to include a larger and more diverse group of experts to enhance the reliability and validity of the AHP results.

5.3 Reflection

5.3.1 Reflection on Methodology

The methodology adopted in this research, focusing on the implementation of IA within MSCM, was designed to extensively explore the potential benefits and challenges of implementing this new technology. The approach adopted in this research can be described as a qualitative-descriptive study. This approach was chosen for its ability to capture detailed insights through multiple forms of data collection, including interviews, surveys, and documents.

The overall strength of this approach was the use of the qualitative descriptive framework, which was particularly useful in capturing detailed insights from participants. The use of open-ended questions in the expert interviews and survey created a comprehensive data collection, which could potentially be overlooked in a more structured quantitative approach.

However, while this approach was suitable for this research, a significant limitation of the methodology was the lack of diversity among the participants of the survey, all of whom were employed at KPMG. This homogeneity may have influenced the research by introducing bias, as all the experiences and perspectives of the participants may not be fully representative of the broader military sector. As mentioned in the limitations, the research could have been enriched by including participants from a variety of consulting firms and military organisations. The qualitative nature of this research, which relies heavily on interviews and open-ended survey responses, carries a significant risk of subjective responses. While trying to reduce the bias potential in the questions and validate the findings, some level of subjective response is unavoidable.

The use of the AHP method, was chosen for its robust framework in dealing with complex decision-making scenarios. AHP provides a structured and systematic approach to organising and analysing decisions involving multiple criteria. AHP's strengths include its ability to incorporate expert judgment, handle both qualitative and quantitative data, and adapt to complex scenarios within the multilayered military organisation . The rationale for using AHP was based on its capacity to handle the complexity of MSCM, provide a comprehensive evaluation of multiple criteria. However, AHP also has some limitations, such as the potential for subjective bias in expert judgments, the complexity of constructing pairwise comparison matrices for a large number of factors, and the challenge of ensuring consistency in judgments. Despite these limitations, the use of AHP in this research has proven to be methodologically sound, offering a detailed analysis that can guide strategic planning and decision-making in a military organisation.

5.3.2 Reflection on Analysis

The qualitative analysis in this research was thorough and provided in-depth insights into complex issues regarding the implementation of IA in MSCM. The overall use of the conceptual framework guided the analysis, which made sure a systematic approach was integrated when coding and interpreting the data. Using this method, recurring themes were identified, such as efficiency, adaptability, resilience, and security. This aided in contrasting a coherent narrative about the potential challenges and benefits of IA. Additionally, the validation of the data gathered from the expert interviews and the community surveys enhanced the credibility and reliability of the findings. By cross-referencing insights from multiple sources, the analysis provided a holistic view, capturing both strategic and operational perspectives on the subject.

This analysis of the gathered data also faced challenges. One of the main challenges was the potential for subjectivity in the thematic interpretation. While this thematic analysis created several themes, which allowed for an easier analysis, it also created the potential for bias.
As mentioned in the reflection of the methodology, efforts were made to reduce the amount of bias in the data by triangulation and systemic coding, but a certain level of bias is inevitable in qualitative research. Another challenge was the qualitative nature of the data, which means that the findings are specific to the context and experiences of the participants. As a result, these findings might not fully capture the broader landscape of IA implementation across different environments.

Overall, the data collection and analysis methods were well-executed, providing valuable insights while maintaining methodological thoroughness.

5.4 Future Research

In the case of future research, some recommendations can be made to broaden the scope and effect of this research. Starting off with the extended scope of this research, as mentioned in the limitations. Gathering information directly from different ministries of defence via interviews or surveys can indicate if the conclusion of this research is only applicable to the Dutch MoD or also to other countries. By not only extending the source of the gathered information but also increasing the amount of data, you can make sure you have all the different sides of a military organisation covered.

In this research, the main objective was to research the differences between a cooperative supply chain and a military supply chain and whether IA implementation could be beneficial. This research concluded that IA implementation is beneficial and therefore worthwhile to investigate in which departments of the supply chain these benefits are the greatest. Since military organisations are often large and complex, it is a difficult task to integrate IA as a whole into the organisation. As suggested by experts A and B, research can be done into specific IA technologies and their effect on specific departments of a military supply chain. This will help with the overall acceptance of IA implementation since the military department could react better to a bottom-up approach, according to expert B.

These are potential research opportunities for leveraging IA to optimise the military supply chain:

- Seek greater technical cooperation and policy alignment of allied countries and partners, regarding the development and implementation of IA technologies. Single handedly focussing on a technology would be a waste of the potential information that can be gathered from allied countries and partners. To overall improve the operation of a military organisation as key aspect is cooperation between other military organisations (D'orazio & Vito, 2014). Ultimately, to achieve successful multinational operations, military leaders should strive for a framework that harmonizes rules of engagement and promotes collaborative efforts.
- Researching the dynamics of human-AI collaboration in military logistics. Developing a framework for effective interaction between human logistics planners and AI systems that assist in decision-making.
- Predictive analytics for supply chain optimisation through integrated advanced predictive algorithms to enhance inventory management and demand forecasting in military supply chains. Researching how these algorithms can predict demand for supplies and equipment in military operation levels of peace, mobilisation, or war. This can be particularly useful in forward operating bases and combat zones where supply chain reliability is crucial.
- Improving customer satisfaction requires the ability to deliver products within a minimum timeframe (Leopold, 2020). This is a factor that has yet to be examined thoroughly.

6 Conclusion

This thesis aimed to explore the integration of IA within MSCM, focusing on understanding its potential benefits, challenges, and implications. The integration of IA uses various technologies, such as AI and RPA, which together can transform the operational landscape of MSCM. By automating routine tasks and providing advanced analytical capabilities, IA has the potential to significantly improve the efficiency and effectiveness of military logistics. The main research question addressed in this thesis was:

What are the key factors when implementing Intelligent Automation into military supply chain management?

The findings in this study indicate that several key factors are crucial for the successful implementation of IA in MSCM. By analysing the information gathered in the theoretical framework in Section 2 and the results shown in Section 4, the most important factors were found and will be described below.

Security regulations will always be an important factor when it comes to the military. This is also the case in this study; a reoccurring topic among the participants and experts was the importance of clear security regulations. Whether this is regarding the fairness of the IA algorithms or the data transfers between different systems (Erich Prem, 2023). These extra guidelines will also make the initial implementation more difficult since this requires comprehensive cybersecurity measures to protect against potential breaches and maintain the integrity of the data.

Due to the nature of a military organisation, it is difficult to incorporate new technologies. This has to do with the existing IT landscape and the hesitant thinking of lower-level military employees. To be able to implement a new technology in such environments, you need to convince people of the numerous benefits it has to offer. Educating people on the usage of these technologies and increasing their overall knowledge is paramount for initiating the first steps of implementation (Barbaroux, 2011).

The sub-questions that were defined to help answer the main research question were also answered by the data collected from the theoretical framework and results. Below, the answers to the sub-questions are summarised:

What are the characteristics of AI and RPA?

This study found that AI and RPA are complementary technologies for the core of IA. AI is characterised by its ability to perform complex tasks that require cognitive functions. It includes capabilities like ML, NLP, and DL. RPA, on the other hand, is a technology that specialises in automating repetitive, high-volume tasks with precision and accuracy. Together, they enable the automation of a wide range of tasks, from simple administrative work to complex analytical processes. By enhancing operational efficiency and decision-making capabilities within MSCM (Ng et al., 2021).

What is the main difference between a commercial supply chain and a military supply chain?

The primary difference between commercial and military supply chains lies in their main focus, operational environments, and security requirements. In a military supply chain, the main focus is to be prepared for all situations, no matter the cost.

This is a different philosophy than that of a commercial supply chain, which seeks opportunities to make the most profit. Within a military supply chain, efficiency is important, but cost efficiency is not their main concern since certain processes need to take place to get certain people or products to specific locations.

Commercial supply chains operate in a relatively stable environment where predictability and cost reduction are important factors. In contrast, military supply chains prioritise reliability, adaptability, and security due to the critical nature of military operations. They must operate efficiently in unpredictable and sometimes hostile environments while ensuring continuous support for military missions (Yoho et al., 2013).

What are the ethical and security aspects of IA usage in a military context?

The ethical and security aspects of IA are significant concerns in its implementation within MSCM. Data security is one of the most important aspects, as military operations involve sensitive information that must be protected against cyber threats and unauthorised access. Ethical considerations include ensuring a transparent and fair deployment of IA systems. It is essential to continuously monitor these systems to prevent bias and maintain the trust gained among personnel. Clear regulations and guidelines are necessary to address these ethical and security issues, ensuring that IA technologies are used responsibly (Hurriye, 2023; Safdar et al., 2020).

In conclusion, IA holds substantial promise for enhancing the efficiency and effectiveness of MSCM. By addressing key factors such as positive adoption, readiness, enhanced efficiency, data security, and building trust, military organisations can leverage IA to achieve greater operational readiness and adaptability.

7 Outlook

This study has demonstrated that IA significantly enhances the efficiency and resilience of military supply chains, offering notable benefits compared to traditional supply chain management practices. To broaden the scope and effect of this research, future studies should consider gathering information directly from various ministries of defence.

This approach could help determine whether the conclusions drawn are applicable solely to the Dutch Ministry of Defence (MoD) or extend to other countries' military organisations.

Increasing the variety and volume of data collected will ensure a comprehensive understanding of different military organizations. While the primary objective of this research was to explore the differences between corporate and military supply chains and the potential benefits of IA implementation, future research could delve deeper into identifying which specific departments within the supply chain would reap the greatest benefits from IA. Given the complexity and size of military organizations, implementing IA holistically can be challenging. Therefore, as suggested by experts, future research could focus on specific IA technologies and their impacts on particular departments within the military supply chain.

This targeted approach could facilitate a more effective and accepted IA implementation, especially through a bottom-up strategy as advised by expert B. Moreover, investigating the dynamics of human-AI collaboration in military logistics could lead to the development of frameworks for effective interaction between human logistics planners and AI decision-support systems.

Additionally, research into predictive analytics for supply chain optimisation, particularly in forward operating bases and combat zones, could enhance inventory management and demand forecasting. Examining factors such as improving customer satisfaction through timely product delivery, as highlighted by Leopold (2020), could provide further insights into the benefits of IA in military logistics.

Exploring the implementation of RAS in military logistics, as seen in recent advancements in military construction efforts (Torossian et al., 2021), can reveal how these technologies improve efficiency and productivity in unstructured and hazardous environments.

These future research directions aim to build on the current understanding, addressing specific challenges and opportunities to further enhance the efficiency, security, and effectiveness of military supply chains.

8 References

1. Abbasi, M., & Nilsson, F. (2012). Themes and challenges in making supply chains environmentally sustainable. *Supply Chain Management*, *17*(5), 517–530. https://doi.org/10.1108/13598541211258582
2. Alguliyev, R., İmamverdiyev, Y., & Sukhostat, L. (2018). Cyber-physical systems and their security issues. *Computers in Industry*, *100*, 212–223.
3. Aljohani, A. (2023). Predictive Analytics and Machine Learning for Real-Time Supply Chain Risk Mitigation and Agility. *Sustainability*, *15*(20), 15088.
4. Aguirre, S., & Rodríguez, A. (2017). Automation of a Business Process Using Robotic Process Automation (RPA): A Case Study. In *Communications in computer and information science* (pp. 65–71). https://doi.org/10.1007/978-3-319-66963-2_7
5. Arenkov, I., Tsenzharik, M., & Vetrova, M. (2019). Digital technologies in supply chain management. *Atlantis Highlights in Computer Sciences, Volume 1*. https://doi.org/10.2991/icdtli-19.2019.78
6. Ballou, R. H., Gilbert, S. M., & Mukherjee, A. (2000). New Managerial Challenges from Supply Chain Opportunities. *Industrial Marketing Management*, *29*(1), 7–18. https://doi.org/10.1016/s0019-8501(99)00107-8
7. Banafa A., (2024). Introudciton to Artificial Intelligence (AI). River Publishers Books. Introduction to Artificial Intelligence (AI) | part of Introduction to Artificial Intelligence (AI) | River Publishers books | IEEE Xplore
8. Barbaroux, P. (2011). A design-oriented approach to organisational change: insights from a military case study. Journal Of Organisational Change Management/Journal Of Organisational Change Management, 24(5), 626–639. https://doi.org/10.1108/09534811111158895
9. Baryannis, G., Validi, S., Dani, S., & Antoniou, G. (2018). Supply chain risk management and artificial intelligence: state of the art and future research directions. *International Journal Of Production Research*, *57*(7), 2179–2202. https://doi.org/10.1080/00207543.2018.1530476
10. Baxter, Pamela and Susan Jack (2008). “Qualitative case study methodology: Study design and implementation for novice researchers”. In: The Qualitative Report 13.4, pp. 544–559.
11. Biona, A., Achantaz, A., Mandvikar, S., “Integrating Data Engineering with Intelligent Process Automation for Business Efficiency”, International Journal of Science and Research Volume 12 Issue 11, 1736-1740, 2023, DOI: https://dx.doi.org/10.21275/SR231123225415
12. Bishop, C. M. B. (2006). Pattern Recognition and Machine Learning. In *Springer eBooks*. https://doi.org/10.1007/978-0-387-45528-0
13. Bonawitz K., Kairouz K., McMahan B. & Ramage D. (2021). Federated Learning and Privacy. *ACM Queue*, *19*(5), 87–114. https://doi.org/10.1145/3494834.3500240
14. Boudreau, J. W., Jesuthasan, R., & Creelman, D. (2015). Lead the Work. In *John Wiley & Sons, Inc. eBooks*. https://doi.org/10.1002/9781119176282
15. Busboom, A. (2024). Automated generation of OPC UA information models — A review and outlook. *Journal Of Industrial Information Integration*, *39*, 100602. https://doi.org/10.1016/j.jii.2024.100602
16. Cebuc, C. N., & Rus, R. V. (2023). The Use of Robotic Process Automation for Business Process Improvement. In *Springer proceedings in business and economics* (pp. 117–131). https://doi.org/10.1007/978-3-031-19656-0_9

17. Chakroborty, A. (2017). *Robotic Process Automation for transforming Financial KPO Industry*. https://www.semanticscholar.org/paper/Robotic-Process-Automation-for-transforming-KPO-Chakroborty/48825b6a313c2bbc92902a5fc952b9ff3b8f8f52
18. Choi, D., R'bigui, H., & Cho, C. (2020). Robotic Process Automation implementation challenges. In *Lecture notes in networks and systems (Online)* (pp. 297–304). https://doi.org/10.1007/978-981-15-7990-5_29
19. Chowdhury, M. M. H., & Quaddus, M. (2016). Supply chain readiness, response and recovery for resilience. *Supply Chain Management*, *21*(6), 709–731. https://doi.org/10.1108/scm-12-2015-0463
20. Christopher, M. (2023). Logistics & Supply chain management. Pearson Education Limited. A01_CHRI_1122_04_SE_FM.indd (ascdegreecollege.ac.in)
21. Coito, T., Viegas, J. L., Martins, M. S.E., Firme, Bernardo, F., Figueiredo, J., Vieira, S. M., Sousa, J. M. C., (2021). The impact of intelligent automation in internal supply chains. *International Journal Of Integrated Supply Management*, *14*(1), 1. https://doi.org/10.1504/ijism.2021.113563
22. Dash, R., McMurtrey, M. E., Rebman, C. M., & Kar, U. K. (2019). Application of Artificial Intelligence in Automation of Supply Chain Management. *Journal Of Strategic Innovation And Sustainability*, *14*(3). https://doi.org/10.33423/jsis.v14i3.2105
23. Davenport, T. H., & Kirby, J. (2016, 15 maart). *Just how smart are smart machines?* MIT Sloan Management Review. https://sloanreview.mit.edu/article/just-how-smart-are-smart-machines/
24. Dey, S., & Das, A. (2019). Robotic process automation: assessment of the technology for transformation of business processes. *International Journal Of Business Process Integration And Management (Print)*, *9*(3), 220. https://doi.org/10.1504/ijbpim.2019.100927
25. Dmytro, B., Volodymyr, R., & Olga, S. (2023, 29 juli). *Factors influencing the efficiency of the organisation of multimodal transportation under the conditions of the state of martial • Intellectualization of logistics and Supply Chain Management*. Intellectualization Of Logistics And Supply Chain Management. https://smart-scm.org/en/journal-19-2023/factors-influencing-the-efficiency-of-the-organisation-of-multimodal-transportation-under-the-conditions-of-the-state-of-martial/
26. D'orazio, Vito James. "International Military Cooperation: From Concepts to Constructs." (2014).
27. Ekström, T., Hilletofth, P., & Skoglund, P. (2020). Differentiation strategies for defence supply chain design. Journal Of Defense Analytics And Logistics, 4(2), 183–202. https://doi.org/10.1108/jdal-06-2020-0011
28. Ettalibi, A., Elouadi, A., & Mansour, A. (2024). AI and Computer Vision-based Real-time Quality Control: A Review of Industrial Applications. *Procedia Computer Science*, *231*, 212–220. https://doi.org/10.1016/j.procs.2023.12.195
29. Etz, D., Brantner, H., & Kästner, W. (2020). Smart Manufacturing Retrofit for Brownfield Systems. *Procedia Manufacturing*, *42*, 327–332. https://doi.org/10.1016/j.promfg.2020.02.085
30. Eulerich, M., Waddoups, N., Wagener, M., & Wood, D. A. (2022). The Dark Side of Robotic Process Automation. *Social Science Research Network*. https://doi.org/10.2139/ssrn.4026996
31. Ferrara, E. (2023). Fairness and Bias in Artificial Intelligence: A Brief Survey of Sources, Impacts, and Mitigation Strategies. *Sci*, *6*(1), 3. https://doi.org/10.3390/sci6010003

32. Flechsig, C., Anslinger, F., & Lasch, R. (2022). Robotic Process Automation in purchasing and supply management: A multiple case study on potentials, barriers, and implementation. *Journal Of Purchasing And Supply Management*, *28*(1), 100718. https://doi.org/10.1016/j.pursup.2021.100718
33. Gartner. (2021). Gartner Says Worldwide Robotic Process Automation Software Revenue to Reach Nearly $2 Billion in 2021. https://www.gartner.com/en/newsroom/press-releases/2020-09-21-gartner-says-worldwide-robotic-process-automation-software-revenue-to-reach-nearly-2-billion-in-2021.
34. Gattorna, J. (2006). *Living supply chains: How to Mobilize the Enterprise Around Delivering what Your Customers Want*. Pearson Education.
35. Geluk, P., Schlueter, M., Thomas, T., & Erkens, S. (2024, 28 maart). *Fixing the Talent Gap in Armed Forces Worldwide*. BCG Global. https://www.bcg.com/publications/2020/fixing-talent-gap-armed-forces-worldwide
36. Griffioen, H., Booij, T. M., & Doerr, C. (2020). Quality Evaluation of Cyber Threat Intelligence Feeds. In *Lecture Notes in Computer Science* (pp. 277–296). https://doi.org/10.1007/978-3-030-57878-7_14
37. Guo, J., Monaikul, N., Plepel, C., & Cleland-Huang, J. (2014). Towards an intelligent domain-specific traceability solution. *ASE '14: Proceedings Of The 29th ACM/IEEE International Conference On Automated Software Engineering*. https://doi.org/10.1145/2642937.2642970
38. Gürtlich, G., & Lampl, S. (2022). Resilience and Military Supply Chain Management. In *Springer series in supply chain management* (pp. 337–352). https://doi.org/10.1007/978-3-030-95401-7_29
39. Ha, Q., Yen, L., & Balaguer, C. (2018, July). Earthmoving Construction Automation with Military Applications: Past, Present and Future. Proceedings of the 35th International Symposium on Automation and Robotics in Construction (ISARC). https://doi.org/10.22260/isarc2018/0164
40. Hamet, P., & Tremblay, J. (2017). Artificial intelligence in medicine. *Metabolism*, *69*, S36–S40. https://doi.org/10.1016/j.metabol.2017.01.011
41. Han, J. H., Kamber, M. K., & Pei, J. P. (z.d.). *Data Mining: Concepts and Techniques*. ScienceDirect. https://www.sciencedirect.com/book/9780123814791/data-mining-concepts-and-techniques
42. Helo, P., & Hao, Y. (2021). Artificial intelligence in operations management and supply chain management: an exploratory case study. *Production Planning & Control*, *33*(16), 1573–1590. https://doi.org/10.1080/09537287.2021.1882690
43. Here, A. (2023, 1 december). *Walmart using AI to streamline organisation.* Supply Chain Today -Homepage.https://www.supplychaintoday.com/walmart-using-ai-to-streamlineorganisation/
44. Hiromoto, R., Haney, M., & Vakanski, A. (2017). *A secure architecture for IoT with supply chain risk management*. https://www.semanticscholar.org/paper/A-secure-architecture-for-IoT-with-supply-chain-Hiromoto-Haney/da60e327b7db8e710d7c23f03db0509b1df6b9a0
45. Houghton, Catherine et al. (2015). "Ethical considerations in qualitative research: A critical reflection". In: Reflective Practice 16.2, pp. 267–277.
46. International Society of Automation (ISA). (z.d.). isa.org. https://www.isa.org/
47. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An Introduction to Statistical Learning. In *Springer texts in statistics*. https://doi.org/10.1007/978-1-4614-7138-7

48. Jayakumar, P.; Brohi, S. N.; Jhanjhi, N. Z. Artificial Intelligence and Military Applications: Innovations, Cybersecurity Challenges & Open Research Areas. Preprints 2021, 2021080047. https://doi.org/10.20944/preprints202108.0047.v1
49. Josyula, S. S., Suresh, M., & Raman, R. (2021). How to make intelligent automation projects agile? Identification of success factors and an assessment approach. *International Journal Of Organisational Analysis*, *31*(5), 1461–1491. https://doi.org/10.1108/ijoa-05-2021-2749
50. Kaledio, P., & Letho, K. (2024). Continuous Monitoring and Improvement: Implement continuous monitoring of AI models to detect and correct issues in real-time.
51. Kaya, C.T., Turkyilmaz, M., Birol, B.: Impact of RPA Technologies on Accounting Systems. Journal of Accounting and Finance. 82, 235–249 (2019)
52. Kovács, G. and Tatham, P.H. (2009), "Responding to disruptions in the supply network – from dormant to action", Journal of Business Logistics, Vol. 30 No. 2, pp. 215-229.
53. Krishnan, K. (2013) 'Data warehousing in the age of big data', Data Warehousing in the Age of Big Data, Newnes, USA.
54. Larson, D., & Chang, V. (2016). A review and future direction of agile, business intelligence, analytics and data science. *International Journal Of Information Management*, *36*(5), 700–710. https://doi.org/10.1016/j.ijinfomgt.2016.04.013
55. Leopold, G., 2020. Military Enlists Digital Twin Technology to Secure Chips. EE Times website.
56. Lubis, L. S., & Sembiring, D. E. (2023). *Driving Digital Transformation: Leveraging Robotic Process Automation (RPA) to Enhance Business Process Efficiency and Reducing Manual Errors*. IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/10291662
57. Lummus, R. R., & Vokurka, R. J. (1999). Defining supply chain management: a historical perspective and practical guidelines. *Industrial Management And Data Systems*, *99*(1), 11–17. https://doi.org/10.1108/02635579910243851
58. McGinnis, M. (1992), "Military logistics: insights for business logistics", International Journal of Physical Distribution and Logistics Management, Vol. 22 No. 2, pp. 22-32.
59. Madakam, Somayya & Holmukhe, Rajesh & Jaiswal, Durgesh. (2019). The Future Digital Work Force: Robotic Process Automation (RPA). Journal of Information Systems and Technology Management. 16. 10.4301/s1807-1775201916001.
60. Meerveld, H., Lindelauf, R., Postma, E. O., & Postma, M. (2023). The irresponsibility of not using AI in the military. *Ethics And Information Technology*, *25*(1). https://doi.org/10.1007/s10676-023-09683-0
61. Mitchell, M. (2006). Complex systems: Network thinking. *Artificial Intelligence*, *170*(18), 1194–1212. https://doi.org/10.1016/j.artint.2006.10.002
62. Mittal, U., & Panchal, D. (2023). AI-based evaluation system for supply chain vulnerabilities and resilience amidst external shocks: An empirical approach. Reports in Mechanical Engineering, 4(1), 276–289. https://doi.org/10.31181/rme040122112023m
63. Moreira, S., Mamede, H. S., & Santos, A. R. (2023). Process automation using RPA – a literature review. *Procedia Computer Science*, *219*, 244–254. https://doi.org/10.1016/j.procs.2023.01.287
64. Morgan, F. E., Boudreaux, B., Lohn, A. J., Ashby, M., Curriden, C., Klima, K., & Grossman, D. (2020). Military applications of artificial intelligence. *Santa Monica: RAND Corporation*.
65. NATO Architecture Framework. Version 4 (2020.09)', Architecture Capability Team, Sep-2020. https://www.nato.int/cps/en/natohq/topics_157575.htm

66. NATO Science and Technology Organisation. (2020). Automation in the intelligence cycle. Retrieved 21 October, 2022, from NATO https://www.sto.nato.int/Lists/STONewsArchive/displaynew sitem.aspx?ID=552
67. Ng, K. M., Chen, C., Lee, C. K., Jiao, J., & Yang, Z. (2021). A systematic literature review on intelligent automation: Aligning concepts from theory, practice, and future perspectives. *Advanced Engineering Informatics*, *47*, 101246. https://doi.org/10.1016/j.aei.2021.101246
68. Nguyen, E. A. , Rexach, C. F., Thorpe, D. P. and Walther, A. E., "The Importance of Data Quality in Software Reliability Modeling," *2010 IEEE 21st International Symposium on Software Reliability Engineering*, San Jose, CA, USA, 2010, pp. 220-228, doi: 10.1109/ISSRE.2010.49.
69. O'Rourke, D. (2014). The science of sustainable supply chains. *Science*, *344*(6188), 1124–1127. https://doi.org/10.1126/science.1248526
70. Okechukwu A. S, Ifeanyi N. C., Lee J. -M. and Kim D. -S., "Machine Learning Algorithm for Intelligent Prediction for Military Logistics and Planning," *2020 International Conference on Information and Communication Technology Convergence (ICTC)*, Jeju, Korea (South), 2020, pp. 417-419, doi: 10.1109/ICTC49870.2020.9289286.
71. Pozzi, R., Rossi, T., & Secchi, R. (2021). Industry 4.0 technologies: critical success factors for implementation and improvements in manufacturing companies. *Production Planning & Control*, *34*(2), 139–158. https://doi.org/10.1080/09537287.2021.1891481
72. Pradeep, A., Rustamov, A., Shokirov, X., Ibragimovna, G.T., Farkhadovna, S. U. and Medetovna, A. F., "Enhancing Data Engineering and Accelerating Learning through Intelligent Automation," *2023 Second International Conference on Trends in Electrical, Electronics, and Computer Engineering (TEECCON)*, Bangalore, India, 2023, pp. 104-110, doi: 10.1109/TEECCON59234.2023.10335832.
73. Prem, E. (2023). From ethical AI frameworks to tools: a review of approaches. *AI And Ethics*, *3*(3), 699–716. https://doi.org/10.1007/s43681-023-00258-9
74. Qian, C., Liu, X., Ripley, C., Qian, M., Fan, L., & Yu, W. (2022). Digital Twin—Cyber Replica of Physical Things: Architecture, Applications and Future Research Directions. *Future Internet*, *14*(2), 64. https://doi.org/10.3390/fi14020064
75. Rahayu, S. B., Sharmelen, A., Vasanthan, L., Azahari, A. M., & Chai, J. (2021). Military Supply Chain Management and Blockchain Development. *AIRCC Publishing Corporation*. https://doi.org/10.5121/csit.2021.111608
76. Reddy KPN, Harichandana U, Alekhya T, and M R. (2019) "A Study of Robotic Process Automation Among Artificial Intelligence". International Journal of Scientific and Research Publications (IJSRP). 2019;9(2):p8651
77. Saaty, R. (1987). The analytic hierarchy process—what it is and how it is used. Mathematical Modelling, 9(3–5), 161–176. https://doi.org/10.1016/0270-0255(87)90473-8
78. Safdar, N. M., Banja, J. D., & Meltzer, C. C. (2020). Ethical considerations in artificial intelligence. *European Journal Of Radiology*, *122*, 108768. https://doi.org/10.1016/j.ejrad.2019.108768
79. Sani, S., Schaefer, D., & Milisavljevic-Syed, J. (2022). Strategies for Achieving Pre-emptive Resilience in Military Supply Chains. *Procedia CIRP*, *107*, 1526–1532. https://doi.org/10.1016/j.procir.2022.05.186
80. Sayler K. M. (2017) Artificial Intelligence and National Security. Congressional Research Service

81. Schwarz, E. (2021). Autonomous weapons systems, artificial intelligence, and the problem of meaningful human control. *Philosophical Journal of Conflict and Violence*.
82. Shavaki, F. H., & Ghahnavieh, A. E. (2022). Applications of deep learning into supply chain management: a systematic literature review and a framework for future research. *Artificial Intelligence Review*, *56*(5), 4447–4489. https://doi.org/10.1007/s10462-022-10289-z
83. Sheffi, Y.& Rice, J. B., Massachusetts Institute of Technology. (2005). *A Supply Chain View of the Resilient Enterprise*. MIT Sloan Management Review. https://sloanreview.mit.edu/article/a-supply-chain-view-of-the-resilient-enterprise/
84. Siderska, J. (2020). Robotic Process Automation — a driver of digital transformation? *Engineering Management in Production And Services*, *12*(2), 21–31. https://doi.org/10.2478/emj-2020-0009
85. Sobb, T. & Turnball, B., *Assessment of Cyber Security Implications of New Technology Integrations into Military Supply Chains*. (2020, 1 mei). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/9283889
86. Sobczak, A. (2019). *Developing a robotic process automation management model*. Lower Silesian Digital Library. https://www.dbc.wroc.pl/publication/143766
87. Srai, J., Settanni, E., Tsolakis, N., & Aulakh, P. (2019, 27 september). *Supply Chain Digital Twins: Opportunities and Challenges Beyond the Hype*. Supply Chain Digital Twins: Opportunities And Challenges Beyond The Hype. https://www.repository.cam.ac.uk/items/0b617edf-397c-43fc-9b25-e3ba34e17e3e
88. Sutipitakwong, S. S., & Jamsri, P. J. (2020, 1 juli). *The Effectiveness of RPA in Fine-tuning Tedious Tasks*. IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/9165452
89. Syed, M. & Suriadi, R. & Adams, S. & Bandara, M. & Leemans, M. & Ouyang, S. J. J. & Ter Hofstede, C. & Van de Weerd, A. H. M. & Wynn, I. & Reijers, H. A. (2020). Robotic Process Automation: Contemporary themes and challenges. *Computers in Industry*, *115*, 103162. https://doi.org/10.1016/j.compind.2019.103162
90. Syntetos, A. A., Babai, Z., Boylan, J. E., Kolassa, S., & Νικολόπουλος, K. (2016). Supply chain forecasting: Theory, practice, their gap and the future. *European Journal Of Operational Research*, *252*(1), 1–26. https://doi.org/10.1016/j.ejor.2015.11.010
91. Tan, K. C., Lyman, S. B., & Wisner, J. D. (2002). Supply chain management: a strategic perspective. *International Journal Of Operations & Production Management*, *22*(6), 614–631. https://doi.org/10.1108/01443570210427659
92. Toorajipour, R., Sohrabpour, V., Nazarpour, A., Oghazi, P., & Fischl, M. (2021). Artificial intelligence in supply chain management: A systematic literature review. *Journal Of Business Research*, *122*, 502–517. https://doi.org/10.1016/j.jbusres.2020.09.009
93. Torossian, B., Bekkers, F., Sweijs, T., Roelen, M., Hristov, A., & Atalla, S. (2020, February). The Military Applicability of Robotic and Autonomous Systems. The Hague Centre for Strategic Studies. https://hcss.nl/report/military-applicability-robotic-and-autonomous-systems
94. Tyagi, A. K., Fernandez, T. F., Mishra, S., & Kumari, S. (2021). Intelligent Automation Systems at the Core of Industry 4.0. In *Advances in intelligent systems and computing* (pp. 1–18). https://doi.org/10.1007/978-3-030-71187-0_1
95. Verschuren, Piet, Hans Doorewaard, and M. J. Mellion (2010). Designing a Research Project. Ed. by M. J. Mellion. 2nd, revised. Eleven International Publishing, p. 312. ISBN: 9059315723, 9789059315723.

96. Voss, M. D., & Williams, Z. (2013). Public–Private Partnerships and Supply Chain Security: C-TPAT as an Indicator of Relational Security. *Journal Of Business Logistics*, *34*(4), 320–334. https://doi.org/10.1111/jbl.12030
97. Wang, T., Liang, Y., Shen, X., Zheng, X., Mahmood, A., & Sheng, Q. Z. (2023). Edge Computing and Sensor-Cloud: Overview, Solutions, and Directions. *ACM Computing Surveys*, *55*(13s), 1–37. https://doi.org/10.1145/3582270
98. Waschull, S., Bokhorst, J., Molleman, E., & Wortmann, H. (2020). Work design in future industrial production: Transforming towards cyber-physical systems. *Computers & Industrial Engineering*, *139*, 105679. https://doi.org/10.1016/j.cie.2019.01.053
99. Webster, F. E. (1992). The Changing Role of Marketing in the Corporation. *Journal Of Marketing*, *56*(4), 1–17. https://doi.org/10.1177/002224299205600402
100. Weisgerber, M., "Defense Firms to Air Force: Want Your Planes' Data? Pay Up," Defense One, September 19, 2017, http://www.defenseone.com/technology/2017/09/military-planes-predictive-maintenance-technology/141133/.
101. Wewerka, J., & Reichert, M. (2021). Robotic process automation - a systematic mapping study and classification framework. *Enterprise Information Systems*, *17*(2). https://doi.org/10.1080/17517575.2021.1986862
102. Willcocks, L. P., Lacity, M. C., & Craig, A. (2017). Robotic Process Automation: Strategic Transformation Lever for Global Business Services? *Journal Of Information Technology Teaching Cases*, *7*(1), 17–28. https://doi.org/10.1057/s41266-016-0016-9
103. Yang, L., Meng, Q., Guo, S., & Zhou, J. (2024). Practice and Enlightenment of General Quality Characteristic Management of Us Military Equipment. In *Studies in systems, decision and control* (pp. 53–67). https://doi.org/10.1007/978-3-031-51719-8_4
104. Yoho, K. D., Rietjens, S., & Tatham, P. (2013). Defence logistics: an important research field in need of researchers. International Journal Of Physical Distribution & Logistics Management, 43(2), 80–96. https://doi.org/10.1108/ijpdlm-03-2012-0079
105. Zavala-Alcívar, A., Verdecho, M., & Alfaro-Saíz, J. (2020). A Conceptual Framework to Manage Resilience and Increase Sustainability in the Supply Chain. *Sustainability*, *12*(16), 6300. https://doi.org/10.3390/su12166300

9 Appendices

A.1 Consent form

Consent form

For the master thesis of Max Akkers it is necessary to use your personal data. To use this data during my research I need your consent.

For what is the data being used?
The data collected is going to be used to make a conceptual framework for the use of Intelligent Automation in Military Supply Chain Management.

What information is going to be used?
In the following table the personal data which will be collected is shown

Category	Personal Data	Purpose
Demographics	Age Gender	To research if these variables have an influence on the viewpoint of the implementation of IA
Job profile	Job location Job experience	To research if these variables have an influence on the viewpoint of the implementation of IA

What happens if I change my mind?
If you change your mind, you can send an e-mail to s3732037@vuw.leidenuniv.nl with a short message indicating that you want your personal data to be removed. Your response will be permanently deleted from the collected data. Any other information that can be traced back to you will also be permanently deleted.

What will be done with my data after the research project?
Your data will be deleted 3 months after the research is concluded.
By checking the box, I acknowledge:

1. My participation in this research project is entirely voluntary. I am under no explicit or implicit pressure to participate, and I understand that I can withdraw at any time without needing to provide a reason. I am not obliged to answer any questions that I prefer not to.

2. I am aware that my personal data will be collected and utilized for the research purposes as detailed in the information sheet provided to me.

A.2 Survey questions

1. Thank you for participating in this survey. The aim of this survey is to gather insights on the usage of **Intelligent Automation (IA) in supply chain management (SCM) and the potential for the use in Military SCM**. I am eager to learn about your insight and understanding of IA.
   Please be assured that your responses are anonymous and will be exclusively used for academic research. Participation in this survey is entirely voluntary, and you may opt out at any time. The survey is designed to take about 5 minutes to complete. To begin, kindly review the consent provided as attachment in my email. If you agree to the terms, please check the consent box below, then you may proceed with the survey.

   I appreciate your contribution to this research project! *

   - ◯ Yes
   - ◯ No

Personal information

2. What is your gender? *

   - ◯ Male
   - ◯ Female
   - ◯ Prefer not to say
   - ◯ Other

3. What is your age? *

   - ◯ 18-24
   - ◯ 25-34
   - ◯ 35-44
   - ◯ 45-54
   - ◯ 55 - 64
   - ◯ 65+

Job information

4. What organization or company are you currently working at? *

- ◯ KPMG
- ◯ Ministry of Defense

5. How long have you been working at this organization? *

- ◯ Less than 1 year
- ◯ 1-2 years
- ◯ 2-3 years
- ◯ 3-4 years
- ◯ 4-5 years
- ◯ More than 5 years

6. Can you describe your role within this organisation? *

Enter your answer

7. How would you rate your technical skills? *

- ◯ Beginner
- ◯ Intermediate
- ◯ Advanced
- ◯ Expert

Knowledge of Intelligent Automation (IA)

8. Are you familiar with Intelligent Automation? *

- ◯ Yes
- ◯ No

9. How would you rate your understanding of the technologies Intelligent Automation and Artificial Intelligence? *

- ◯ No understanding
- ◯ Basic understanding
- ◯ Moderate understanding
- ◯ Advanced understanding
- ◯ Expert understanding

Benefits and challenges

These questions are related to the potential benefits and challenges if IA is successfully implemented in a military organization. You're either on the KPMG project at the Ministry of Defense (MoD) or a MoD employee. Answer these questions as if IA would be implemented in the supply chain at the MoD.
Military Supply Chain Management (MSCM) is the procurement, processing, and distribution of military resources.

If you want learn more about Intelligent Automation before answering the following questions click the link below:
<https://www.automationanywhere.com/rpa/intelligent-automation>

10. Do you think Intelligent Automation can make a difference within MSCM? *

- ○ Stronly disagree
- ○ Disagree
- ○ Neither disagree nor agree
- ○ Agree
- ○ Strongly agree

11. Which aspect of MSCM do you think benefits most from IA? **(Multiple choices allowed)** *

- ☐ Adaptability
- ☐ Resilience
- ☐ Incident Response
- ☐ Quality Control
- ☐ Other

12. Please indicate what impact the following statements, you think, might have on MSCM. *

	Minimal impact	Low impact	Moderate impact	High impact	Very high impact
The impact of IA on the speed of operations in MSCM:	◯	◯	◯	◯	◯
The impact of enhanced adaptability through IA on MSCM's ability to respond to unexpected challenges:	◯	◯	◯	◯	◯
The impact of incident response improvements through IA on overall military readiness:	◯	◯	◯	◯	◯
The impact of quality control automation on product and service reliability in MSCM:	◯	◯	◯	◯	◯

13. To what extend do you agree with the following statements: *

	Stronlgy disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
IA is likely to lead to significant job displacement	◯	◯	◯	◯	◯
The technology infrastructure can support the integration of IA without major upgrades.	◯	◯	◯	◯	◯
Implementing IA will require significant changes to the workflow and operations.	◯	◯	◯	◯	◯
MoD is prepared and willing to adapt to changes brought by IA.	◯	◯	◯	◯	◯
Implementing IA can increase the information transfer between systems	◯	◯	◯	◯	◯

14. What do you think are the biggest challenges when integrating IA into MSCM? *

Enter your answer

15. Please describe any personal experiences or observations where IA has impacted MSCM. (Optional)

Enter your answer

Risks and ethical considerations

16. I don't feel comfortable with the use of Artificial Intelligence within the military *

- Strongly disagree
- Disagree
- Neither disagree nor agree
- Agree
- Strongly agree

17. The potential benefits are worth the potential additional security risks when implementing IA? *

- Yes
- No

18. Please indicate the strength of your disagreement/ agreement with the following statements:
*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
IA introduces significant cyber security risks to a military organization.	◯	◯	◯	◯	◯
The benefits of IA in military supply chains outweigh the ethical concerns it may raise.	◯	◯	◯	◯	◯
There should be strict regulations governing the use of IA to protect privacy and data integrity.	◯	◯	◯	◯	◯
Organizations should prioritize transparency when deploying IA technologies.	◯	◯	◯	◯	◯
IA should be implemented in a way that complements human skills, not replaces them.	◯	◯	◯	◯	◯

19. What are your primary concerns regarding the use of IA in MSCM from a security standpoint?
*

Enter your answer

B.1 Expert interview guidelines

- What is you background and current occupation?

- What is your experience with the Ministry of Defence (MoD), what projects have you worked on?

- How do you experience the adoption of new technologies within your department at MoD?

  Explain the details of the constructed framework

- Which features of IA could have the most impact on improving MSCM?

- What are the most common challenges when implementing a new technology within MoD?

- Are some benefits or challenges not mentioned within the conceptual framework?