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Upgrading Traditional Automation With Robotic Process Automation In Digital Transformation

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ABSTRACT:

The digital transformation of enterprises is a comprehensive process in which Robotic Process Automation (RPA) is a significant factor in enhancing efficiency and competitiveness. This thesis studies the integration of RPA in upgrading traditional automation systems within a global company's Master Data Management (MDM) department, examining the consequences on sustainable competitive advantage and departmental operations. The empirical research, drawing on the Manufacturing Strategy Index (MSI) and the Sense and Respond (S&R) frameworks, evaluates the alignment of RPA implementation with corporate strategies focused on cost, quality, delivery, and flexibility. The study provides a comprehensive analysis of resource allocation, operational risks, and strategic positioning through a combination of qualitative and quantitative methods—particularly AHP, CFI, BCFI, and NSCFI models. The findings reveal that RPA, particularly through UiPath's platform, not only reduces operational costs but also enhances accuracy and speed, resulting in a shift in departmental strategy towards more agile and proactive processes. Through a comprehensive analysis underpinned by models of strategic coherence and effectiveness, this thesis plans and presents a roadmap for integrating RPA into corporate processes, offering insights into the broader discourse on digital evolution in organizational environments.

KEYWORDS: Robotic Process Automation, Sustainable Competitive Advantage, Traditional Automation

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ABBREVIATIONS

AHP	=	Analytic Hierarchy Process
BCFI	=	Balanced Critical Factor Index
CFI	=	Critical Factor Index
CV	=	Coefficient of Variation
ERP	=	Enterprise Resource Planning
MAD	=	Maximum Deviation
MAPE	=	Mean Absolute Percentage Error
MDM	=	Master Data Management
MMD	=	Material Master Data
MSI	=	Manufacturing Strategy Index
NSCFI	=	New Scaled Critical Factor Index
RAL	=	Responsiveness, Agility, and Leanness
RPA	=	Robotic Process Automation
RMSE	=	Root Means Squared Error
SCA	=	Sustainable Competitive Advantages
SCFI	=	Scaled Critical Factor Index
S&R	=	Sense and Respond
T&K	=	Technology and Knowledge

1. INTRODUCTION

In today's era of rapid technological advancement, enterprises must engage in digital transformation to enhance operational processes and maintain a competitive edge (Loshin, 2010; Schwab, 2017). This transformation disrupts conventional business frameworks by introducing more efficient methods and facilitating collaborations across diverse sectors.

A key catalyst in this shift is Enterprise Resource Planning (ERP) systems, which integrate and unify core business functions such as finance, human resources, supply chain, and production management, providing a centralized platform for efficient information flow and resource management (Al-Mashari et al., 2003; Davenport, 1998). ERP systems improve decision-making and streamline workflows, creating a foundation upon which automation technologies like Robotic Process Automation (RPA) can be layered (Moon, 2007). RPA is a complementary technology that automates repetitive, rule-based tasks within ERP systems, freeing employees from manual tasks and further enhancing productivity and accuracy (Hofmann et al., 2020; Ribeiro et al., 2021). Together, ERP and RPA systems enable organizations to achieve real-time data accuracy, optimize resource allocation, and increase overall operational efficiency, which is critical for remaining competitive in a fast-paced business environment (Asatiani & Penttinen, 2016).

Notably, multinational corporations like Wärtsilä Corporation—a Finnish company renowned for its marine engine production—are proactively embracing these technological advancements. Wärtsilä has strategically aligned itself with global decarbonization initiatives, and in 2022, it established the Sustainable Technology Hub (STH) in Vaasa to advance its manufacturing processes and data analytics capabilities. This facility leverages RPA among other technologies to enhance operational efficiency and reduce costs, underscoring Wärtsilä's commitment to sustainable, tech-driven growth (Wärtsilä Corporation, 2022).

Discussing how technologies like RPA influence business strategy holds practical significance. While RPA is a powerful transformative agent within an organization's operational structure, its benefits should not lead to hasty, blanket adoption (Jovanović et al., 2018). Instead, incorporating RPA should result from a careful selection of processes for automation, tied to an ongoing analysis of each organization's unique architecture (Lindström et al., 2018). A clear academic consensus emerges: to leverage core technologies like RPA for operational improvement and secure a competitive advantage, companies must thoroughly review their operational processes. Therefore, exploring how RPA can be strategically implemented to enhance business performance, particularly in the context of environmental change, is of significant interest. This research interest lies in exploring how RPA can be strategically implemented to enhance business performance, particularly in the context of environmental change.

1.1 Research Field

The research area primarily lies at the intersection of the following disciplines:

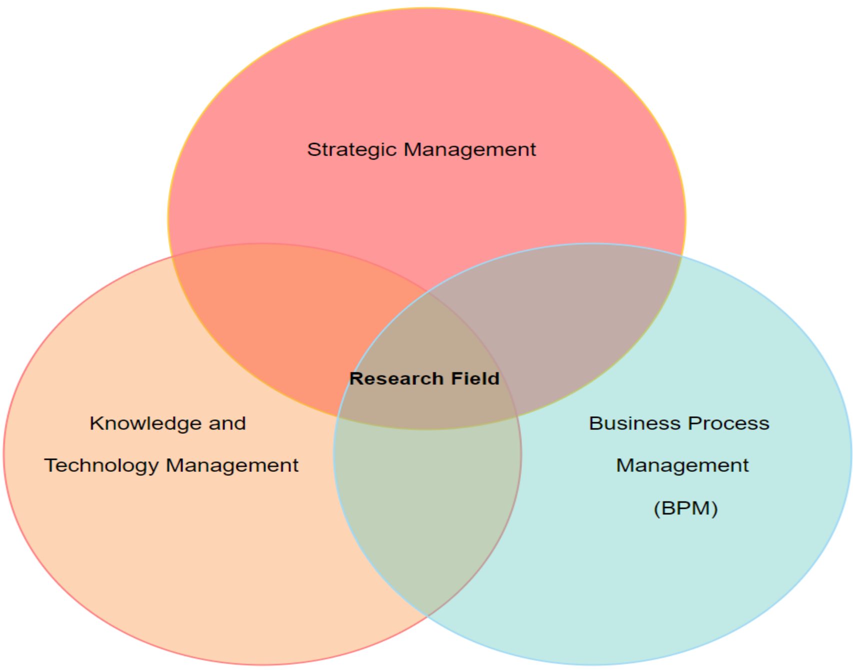


Figure 1. Research Field Circle

(1) Strategic Management

Strategic management focuses on the formulation and implementation of a company's overall strategy. In this context, attention is given to how a department's strategy aligns with the company's strategy following the introduction of RPA (Robotic Process

Automation). This alignment falls within the scope of strategy implementation, exploring how to ensure that departmental strategies remain consistent with the organization's overall strategic direction, particularly when adopting or transforming through new technologies.

(2) Knowledge and Technology Management

Knowledge and Technology Management explores the strategic implementation and integration of advanced technologies to drive organizational effectiveness. This area emphasizes the role of new technologies in reshaping traditional processes, fostering innovation, and achieving sustainable competitive advantage. By adopting an evidence-based approach, this discipline examines how carefully aligned technological advancements can support long-term organizational objectives and enhance operational agility (Hofmann et al., 2020; Takala et al., 2013). It also involves analyzing the risk and impact associated with different levels of technological integration, ensuring a balanced approach that aligns with the organization's strategic direction (Lindström et al., 2018)

(3) Business Process Management (BPM)

RPA, as an automation technology, is closely tied to business process optimization. In this framework, the alignment of departmental strategies involves examining how RPA can enhance departmental efficiency while ensuring coherence with the company's overall strategy.

1.2 Research Objective and Questions

The objective of this research is to analyze the department's competitive focus on cost, quality, delivery, and flexibility. The ultimate goal is to explore the potential of RPA (Robotic Process Automation) in facilitating departmental transformation and improvement, thereby contributing to sustainable development within the organization. This study serves as a pilot for a more comprehensive future investigation.

Research entity: Material Master Data (MMD) department.

The following research questions have been proposed:

1. What is the prevailing strategy of the Material Master Data department?

2. By implementing new technology such as Robotic Process Automation in MMD, does the automated system meet the department's strategy expectations regarding cost, quality, delivery, and flexibility?

1.3 Research Design

The research design of this study is structured using the research onion framework introduced by Saunders et al. (2007). This model provides a systematic approach to organizing methodological choices by breaking them down into distinct layers, each contributing to a coherent and robust research process.

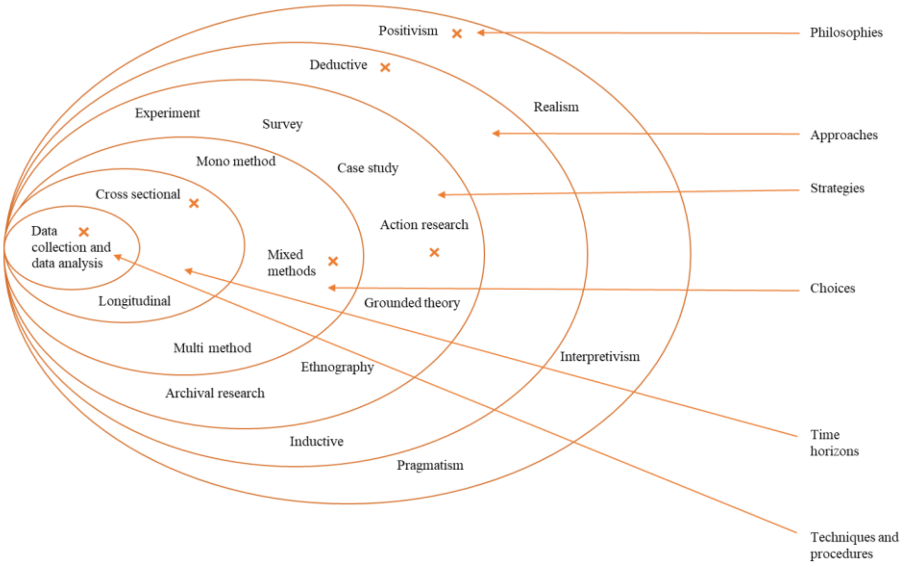


Figure 2. Mapping research methods on the research onion

(1) Research Philosophy: Positivism

The research adopts positivism as its philosophy, which is appropriate for studies aimed at objective analysis and the measurement of observable phenomena, especially in empirical research. Positivism emphasizes quantifiable data and logical reasoning, allowing for a structured approach to assess risk levels and resource allocation in the conglomerate's strategic management (Saunders et al., 2007). This philosophy is often used in studies that aim for generalizability and the discovery of universal laws or principles, such as in risk assessment and decision-making optimization (Remenyi et al., 1998).

(2) Research Approach: Deductive and Inductive

A deductive approach is employed to test existing theories (e.g., resource-based theory and sustainable competitive advantages) in the context of RPA implementation, making it suitable for the research's objective to identify risk levels and critical factors for resource allocation. Deduction involves formulating hypotheses based on theory and using empirical data to confirm or refute them (Hyde, 2000). In contrast, inductive logic is used in qualitative aspects of the study, such as the analysis of sustainability goals, where the researcher interprets data from observations and conversations to generate new insights and guidelines (Bryman & Bell, 2011). This mixed approach allows for both theory testing and theory building.

(3) Research Strategy: Mixed Methods

The use of a mixed methods paradigm, integrating both quantitative (AHP, S&R model, CFI method) and qualitative analysis (observations, interviews), aligns with the methodological choice layer of the research onion. Mixed methods allow for the combination of statistical data and in-depth qualitative insights, which is particularly useful for understanding complex environments like the MMD department within a conglomerate undergoing transformation (Creswell, 2014). By combining these methods, the study offers a more comprehensive understanding of the phenomena.

(4) Research Time Horizon: Cross-Sectional

The study likely uses a cross-sectional time horizon, as data is collected at a specific point in time (e.g., during the sustainability transformation and RPA implementation). Cross-sectional studies are well-suited for analyzing the current state of resource allocation and decision-making processes, providing a snapshot of the organization's strategic management challenges (Saunders et al., 2007).

(5) Techniques and Procedures: Data Collection and Analysis

The data collection methods, such as face-to-face interviews and questionnaires, align with the final layer of the research onion, which focuses on techniques and procedures. Quantitative data is analyzed using error metrics like MAPE, RMSE, and MAD, essential for evaluating the accuracy of resource allocation strategies. Qualitative data, gathered through interviews and unstructured discussions, provides deeper insights into the organizational culture and strategic goals. The use of action research further emphasizes the study's focus on practical problem-solving and iterative improvements, making it ideal for applied research in professional and scientific settings (Reason & Bradbury, 2001).

(6) Implementation process

The RPA implementation in this study will not modify the backend logic of the system and therefore represents a lower-risk and less labor-intensive process automation solution (Lacity & Willcocks, 2016). RPA will replicate ERP database maintenance by extracting, modifying, adding, or deleting database information within the ERP system before writing it back into the system. It mimics human actions within a set framework to improve service efficiency and competitiveness.

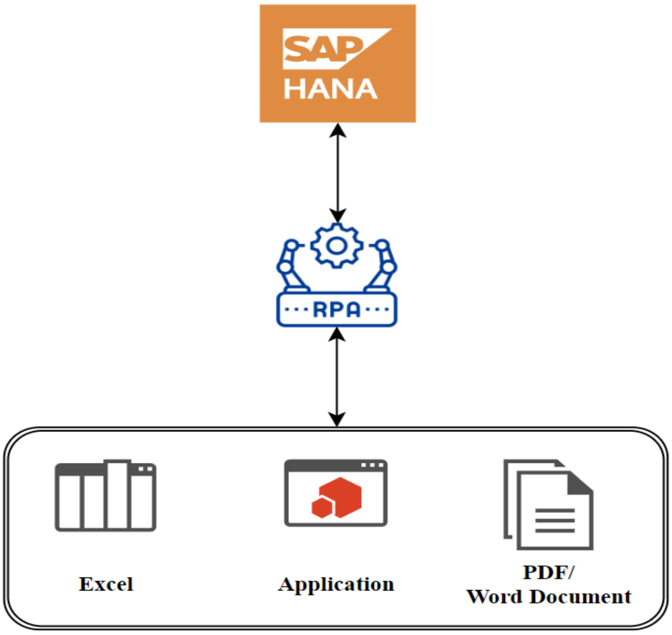


Figure 3. Illustration of an RPA use case

Regarding the choice of RPA software, the target company decided in 2016 to adopt UiPath as the standard tool for all operations. Due to company policy, this study exclusively utilizes UiPath for building RPA solutions, without engaging in cross-comparisons of different RPA software.

1.4 Research Process

This study's process was inspired by Timilsina’s Strategy Framework for effective and efficient operations, strategic planning, implementation, and monitoring (Timilsina, B., 2017). Past experiences and future expectations remain critical dimensions in assessing strategic direction. This influence stems from two key factors: First, past experiences provide a foundation for present actions, which, in turn, shape future expectations. Second, to achieve organizational objectives, present actions must be continuously adapted to align with the evolving business environment. In this study, the introduction of RPA (Robotic Process Automation) and shifts in regulatory policies necessitate modifications to strategies, ensuring the firm remains responsive and adaptive in a dynamic landscape. Accordingly, Timilsina’s Strategy Framework was revised by removing irrelevant components, such as "analysis of industry forces" and "Target Release Processing and Audition," and adjusting "strategy workshop" and "systematic mapping of possibilities" to "mapping of possible RPA implementations."

Following this logic, the post-RPA implementation was evaluated across four dimensions: quality, time, flexibility, and cost, to ensure alignment with departmental strategies.

This framework is illustrated in Figure 4.

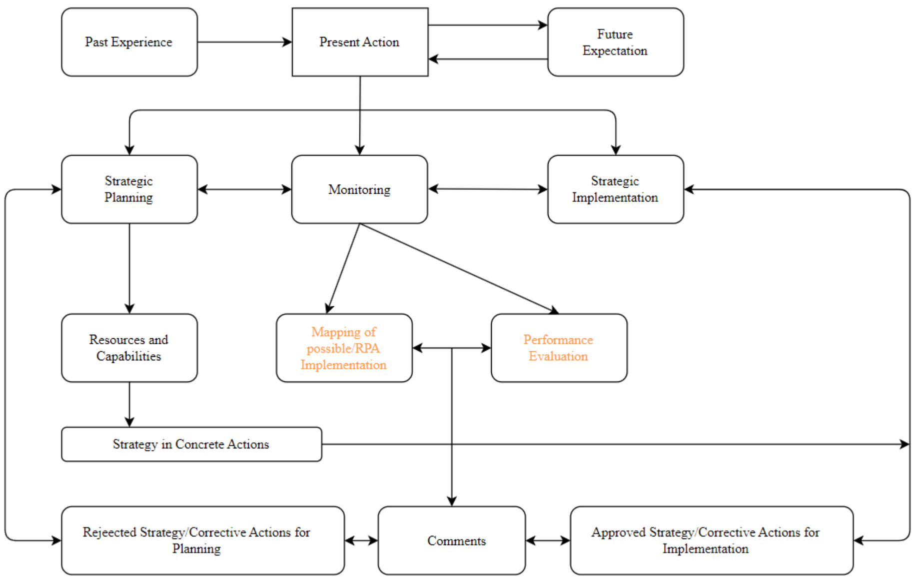


Figure 4. Adjust Framework for effective and/or efficient strategic planning and implementation (Source: Timilsina,B. (2017))

The Next step in collecting data is to interview management-level candidates face-to-face. Since the data involves comparing multiple parameters and calculating their weights, it's important to pay attention to the logical relationships and check for any contradictions during the data collection, ensuring that all consistency ratios meet the previously set thresholds.

Subsequently, during the analytical phase, the Manufacturing Strategy Index (MSI) questionnaire responses were inputted into Goepel's AHP Priority Calculator to ascertain the consistency ratio (Goepel, 2018).

The data amalgamated from both questionnaires were meticulously transferred to a bespoke Excel template designed for the Sense and Respond (S&R) method, as outlined by Timilsina in "TUTA3080: Operations Strategy" (Timilsina, 2022). Upon data importation, the analysis results were instantly accessible. These findings were interpreted with rigor, based on an established theoretical framework.

Additionally, a Robotic Process Automation (RPA) model is to be developed for juxtaposition with conventional automated methodologies. The study's findings will be compiled and presented upon the conclusion of the analysis.

2. LITERATURE REVIEW

In the present era of technological advancement, enterprises must engage in digital evolution to enhance operational processes and retain a competitive edge. Digital transformation enables businesses to disrupt conventional frameworks, introducing more efficient methods that facilitate collaborations across diverse sectors (Loshin, 2010; Schwab, 2017). Core to this transformation are technologies like Enterprise Resource Planning (ERP) and Robotic Process Automation (RPA). ERP systems lay the foundation for integrated, real-time information sharing across business functions, enhancing strategic decision-making by centralizing data from finance, operations, human resources, and supply chain processes (Davenport, 1998; Moon, 2007). ERP serves as the operational backbone for many organizations, providing a centralized framework that not only supports daily operations but also aligns with strategic objectives (Georgakopoulos et al., 1995; Gupta & Kohli, 2006).

Robotic Process Automation (RPA), a complementary technology, automates repetitive tasks previously performed by humans, paving the way for increased efficiency and cost-effective operations (Hofmann et al., 2020; Ribeiro et al., 2021). Integrating RPA into ERP systems creates synergies by enhancing ERP's data processing capabilities, thereby enabling companies to achieve end-to-end automation across various functions. Studies such as Takala et al. (2013) have examined how technological advancements contribute to achieving sustainable competitive advantage within businesses. Their findings suggest that the application of knowledge and technology, through ERP and RPA integration, can lead to diverse strategies that establish reliable and efficient operational processes. As ERP systems continue to evolve with advanced analytics and automation, they enable organizations to align resources with corporate objectives, improving agility and responsiveness to market changes (Gupta & Kohli, 2006; Georgakopoulos et al., 1995).

While RPA is a powerful transformative agent within an organization's operational structure, its benefits should not lead to hasty, blanket adoption (Jovanović et al., 2018). Incorporating RPA should result from a discerning selection of processes for automation, tied to an ongoing analysis of each organization's unique architecture (Lindström et al., 2018). Combining insights from Takala's and Lindström's studies, a clear academic consensus emerges: to leverage core technologies like RPA for operational improvement and secure a competitive advantage, companies must thoroughly review their operational processes. This rigorous approach ensures that the organization’s digital transformation efforts align with its strategic objectives, optimizing resource allocation and minimizing disruption (Asatiani & Penttinen, 2016; Davenport, 1998).

Both business and academic landscapes recognize the strategic significance of RPA as an enhancer of manufacturing operations strategy (Hofmann et al., 2020). Integrating RPA within manufacturing systems not only drives efficiency but also positions businesses to leverage Sense and Respond mechanisms effectively (Vacante, 2007), adapting real-time responses to market dynamics. These operational strategies, underpinned by methods such as the Analytic Hierarchy Process (AHP), facilitate priority setting and informed decision-making, streamlining processes leading to sustainable competitive advantages (Vaidya & Kumar, 2006). Furthermore, effective use of the Critical Factor Index (CFI) distinguishes success from mediocrity in unraveling complex strategic decisions in manufacturing (Nadler & Takala, 2008). The CFI quantifies critical determinants in operational success and strategic advantage, converging technology and operational acumen into a highly competitive strategy.

2.1 Manufacturing Strategy Index (MSI)

The Manufacturing Strategy Index (MSI) is a model that aids in determining the level of operational competitiveness within an organization (Miles et al., 1978). Ranking multi-factors such as quality (Q), cost (C), time (T), and flexibility (F) are part of this procedure. It's worth noting that the creation of the MSI model was originally intended to help organizations classify their business strategies.

The MSI evaluates the company's leadership and its approach towards resource development. Based on Miles and Snow (1978) distinct strategy topologies exist, namely: Prospector, Defender, Analyzer, and Reactor.

A company adopting the Prospector strategy prioritizes product innovation and incessantly looks for novel product-market possibilities. Such companies tend to encompass a forward-thinking outlook with a focus on research, development, pioneering, and risk-taking. In markets or industries where technological advancement is constant evolving, this strategy tends to grow, and it lauds quality above all.

Conversely, Defender companies aim to enhance the efficiency of their current operations, offerings, and services. Cost-effectiveness forms the core of the Defender's strategy, which is most effective in scenarios where there is limited room for innovation. Defender organizations strive for market share maintenance rather than new market development.

Companies adopting the Analyzer strategy fuse features of both Prospector and Defender strategies. These companies closely monitor market trends, incorporate successful competitors' tactics, and efficiently imitate new advancements. This practical approach allows them to rapidly adapt to changes within the industry while securing their market position.

Reactor companies, lacking a distinct strategy, objectives, and goals, adapting respond to fluctuating business environments. They exhibit no strategic orientation.

MSI leverages the Responsive, Agility, and Leanness (RAL) model, proposed by Takala (Takala & Rautiainen, 2003). It does this to identify a company's selected business strategy`s nature.

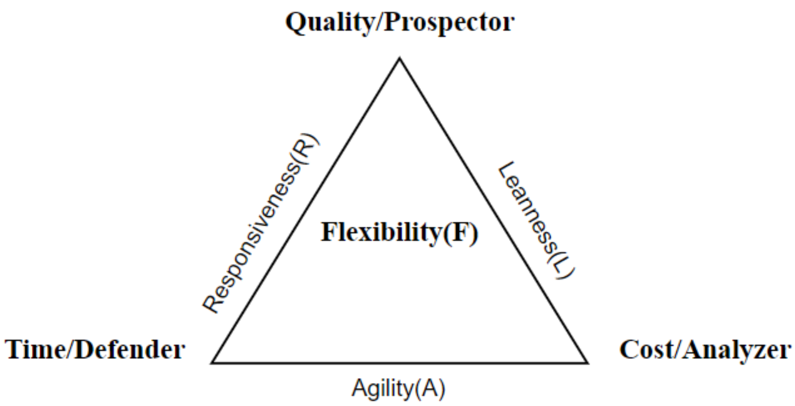


Figure 5. RAL Model (Source: (Liu & Takala, 2012))

2.2 Sense and Respond (S&R)

The 'Sense & Response' framework, developed by Bradley (Bradley & Nolan, 1998), offers a scalable managerial approach adept at fluidly integrating organizational enhancements (Bradley & Nolan, 1998). Adaptable organizations that view changes in their environment as chances for progress or as signs of potential risk are better positioned to embrace transformation. (Dunford et al., 2013). This flexibility is realized through agile processes that accelerate reactions to emergent demands, fostering a dynamic learning ecosystem (Antonacopoulou & Gabriel, 2001).

At the core of this process is a feedback loop crucial for shaping organizational activities. It requires a careful examination of management systems, unique structural features, and operational requirements. The agility and responsiveness of these systems ensure the standard of service provided (Gmach et al., 2008).

In modern economies characterized by unpredictable fluctuations (Haeckel, 1999), businesses grapple with the consequence of rapid economic transformations. To thrive, companies are urged to transition from a product-centric to a process-centric orientation, empower those at the operational forefront, and cultivate an acute sensitivity to customer needs. The 'Sense and Respond' tactic is a beacon of adaptability, particularly in the strategic operational area, as the 'Sense and Respond' tactic becomes a beacon of adaptability(Haeckel, 1992).

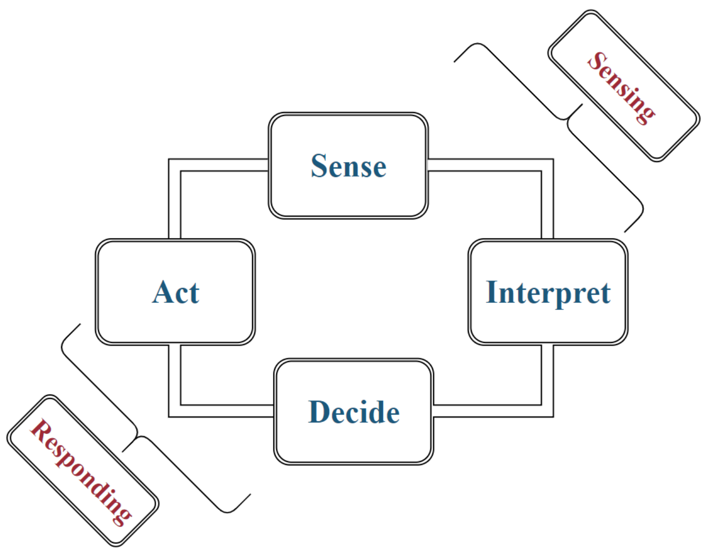


Figure 6. The Adaptive loop (Source: (Haeckel, 1992)).

The conceptualization of the 'Sense and Respond' method was seminal to Haeckel (1992) and was later refined by Bradley and Nolan (1998). This approach aspires to devise mechanisms to counter challenges arising from sudden and vital shifts in continual processes (Haeckel, 1992).

2.3 Enterprise Resource Planning (ERP)

Enterprise Resource Planning (ERP) has evolved over several decades, becoming a cornerstone for managing integrated business processes across various sectors. Initially, ERP systems emerged in the 1960s as basic inventory management and control systems, focusing on automating repetitive tasks and managing resources more efficiently. These early systems laid the groundwork for Material Requirements Planning (MRP) software, which addressed manufacturing needs and provided a systematic approach to managing production processes (Davenport, 1998). In the 1980s, the scope of ERP expanded with the introduction of Manufacturing Resource Planning (MRP II), which integrated additional functions like finance and human resources, allowing organizations to manage various operational aspects within a single platform (Georgakopoulos et al., 1995).
By the 1990s, ERP systems had grown in sophistication, incorporating comprehensive tools that facilitated real-time information sharing and decision-making across departments. During this period, large-scale organizations began to adopt ERP systems to unify their complex global operations, achieving standardization and improved efficiency (Gupta & Kohli, 2006). With advancements in digital technology, modern ERP systems now feature enhanced analytics and cloud-based functionalities, providing more flexible and scalable solutions to meet the demands of today's digital economy (Miles et al., 1978)
The evolution of ERP has set the stage for further advancements in automation, as exemplified by the integration of ERP with Robotic Process Automation (RPA). This integration allows for the automation of routine, high-volume tasks within ERP systems, optimizing workflow efficiency and accuracy (Asatiani & Penttinen, 2016). In contemporary

settings, ERP remains vital for aligning business operations with strategic objectives, serving as a foundational platform for digital transformation efforts.

2.4 Robotic Process Automation (RPA)

Robotic Process Automation (RPA) encompasses tools that interact with computer systems' user interfaces as a human would, specifically within the front-end graphical user interface (Aalst et al., 2018). Essentially, RPA serves as a technological replication of human employee actions, aiming to perform manual and structured tasks in an efficient and cost-effective manner (Asatiani & Penttinen, 2016). Unlike traditional software that engages with systems through back-end integration, RPA is implemented as a software robot, emulating human interactions with software applications, such as ERP systems or other productivity tools (Asatiani & Penttinen, 2016). RPA tools are designed to alleviate the burden of repetitive tasks typically performed by employees, applying automation to specific activities or entire processes autonomously (Baranauskas, 2018).

Three key technologies for RPA products respectively: Screen scraping、workflow automation and management tools (Ostdick 2016).

Screen scraping, a specific type of data scraping, involves the automatic extraction of data displayed on a screen, which can originate from various sources such as applications, web pages, terminals, or documents (Ostdick, 2017). This technique allows contemporary applications to interface with legacy systems that lack an API or alternative methods for accessing source data. Furthermore, screen scraping is employed in situations where data needs to be harvested from web presentations, such as the HTML layer, utilizing technologies like web scraping or optical character recognition (OCR) (Ostdick, 2016)

Workflow Management Systems (WfMS), commonly referred to as workflow automation, are advanced information technologies crafted to automate business processes by managing and directing the flow of work and information among participants (Hollingsworth, 1995). These systems act as integrative software or interfaces that connect various office applications within an enterprise, streamlining not just task coordination but also the management of internal information flows (Georgakopoulos et al., 1995). Certain comprehensive systems, such as Enterprise Resource Planning (ERP) systems, have integrated these workflow automation capabilities directly into their software suites (Davenport, 1998).

The evolution of Workflow Management Systems (WfMS) has given rise to Business Process Management (BPM) systems, which place a greater emphasis on the management aspect of processes (Ter Hofstede,et al., 2003). BPM extends the foundational principles of scientific management introduced by Frederick Winslow Taylor by integrating contemporary methodologies aimed at enhancing process quality and efficiency. This integration includes techniques advocated by Peter Drucker, as well as the principles of Total Quality Management and Six Sigma methods, to provide a comprehensive framework for process improvement (Hammer, 2015).

RPA distinguishes itself from BPM systems in several key aspects. As shown in Figure 7, BPM systems typically developed by IT staff, represent substantial IT investments due to the necessity for redesigning both the business logic layers and data access layers (Weske, 2012).

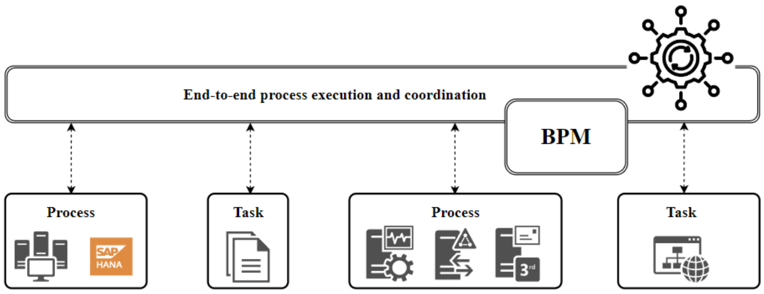


Figure 7. Pictorial demonstration of BPM

In contrast, RPA operates by accessing systems through the presentation layer, allowing even business users to design workflows without altering the underlying systems (Aguirre & Rodriguez, 2017). RPA technologies automate repetitive business processes, emulating human actions within a set framework to augment service effectiveness and drive competitiveness (Osman, 2019).

The traditional method for enhancing information systems typically involves the integration of systems through backend processes or the utilization of Application Programming Interfaces (APIs), a strategy often referred to as the "inside-out" approach. This method aims to improve the system's overall structure but tends to demand significant resources, extensive IT knowledge, and a prolonged implementation period (Erl et al., 2016). In contrast, the "outside-in" approach advocates for system improvements that do not alter the underlying information systems, offering a more agile and streamlined method. RPA adopts this latter approach, presenting advantages such as reduced effort and time required for implementation (Aguirre & Rodriguez, 2017).

	RPA	BPM
Focus	Automatiing existing processes	Understanding existing process to roll out new ones
Scope	Tactical approah for automation existing processes	strategic approach encompassing all aspects of process improvement
Deployment effort	models the way users interact with existing apps to automate process tasks	Interprets existing processes to identify opportunities for improvement and the implementing new processes
Role	speeds execution of existing processes	Facilictates business process re-engineering
Automation	Automates repetitive processes	Process mining and cature help understand existing processes
Tools	Narrower set of tools that mimic the way users click and type their way through applications	Broad collection of tools for proces mapping, visualization, low-code development and RPA

Table 1. Comparison of RPA and BPM (Source: Team Kissflow (2024))

The comparison of Table 1 shows that although RPA and BPM have some differences, the whole still exhibits a synergistic relations, wherein RPA is focused on automating designated tasks, while BPM is tasked with identifying which tasks should be automated and determining the necessary steps for their elimination or integration (Aalst et al., 2018). The choice of different automation solutions for different scenarios is an emerging issue.

RPA has evolved through several stages, becoming more advanced and autonomous at each step.

- Initially, RPA 1.0 served as a basic "virtual assistant" on employee PCs to streamline tasks, although it was limited in its ability to automate complex processes (Lacity & Willcocks, 2016).
- The next stage, RPA 2.0, functioned as a "virtual workforce," capable of more independent operation and centralized management, leading to increased efficiency and cost savings (Syed et al., 2020).

- RPA 3.0 expanded these capabilities to the cloud, allowing for even greater automation and scalability, although it still struggled with unstructured data (Aguirre & Rodriguez, 2017).
- The future phase, RPA 4.0, is expected to incorporate artificial intelligence and machine learning, enabling the automation of more complex tasks and decision-making processes (Kaplan & Haenlein, 2020).

Robotic Process Automation (RPA) has revolutionized manufacturing by streamlining repetitive tasks and improving operational efficiency. In manufacturing, RPA integrates with various systems to perform tasks traditionally done by humans, such as data entry, monitoring systems, and triggering specific actions based on predefined rules. RPA allows manufacturing firms to optimize production by reducing manual effort, minimizing errors, and accelerating workflow processes (Pasupuleti, 2024). This technology facilitates not only cost savings but also enhances overall productivity, especially when integrated with AI and other advanced automation technologies (Vadivel, 2024).

RPA operates by mimicking human interactions with software interfaces, allowing it to autonomously carry out structured and repetitive tasks. This is particularly useful in scenarios involving large-scale data handling and process standardization, such as in Enterprise Resource Planning (ERP) systems (Pardesi, 2024).

Recent advancements in hyper-automation, which combine RPA with AI, have further enhanced RPA’s potential by enabling more intelligent decision-making processes and seamless end-to-end automation (Pardesi, 2024). As manufacturing industries move towards Industry 5.0, the integration of AI with RPA has allowed manufacturers to achieve higher levels of efficiency and sustainability by automating complex processes and improving real-time decision-making (Vadivel, 2024). Furthermore, AI-driven RPA tools are increasingly being used to optimize green supplier selection and improve sustainability efforts in manufacturing (Anvarjonov et al., 2024).

3. METHODOLOGY

In this section, a comprehensive overview of the methodologies and analytical techniques adopted is presented.

3.1 Case Study Method

A case study constitutes a comprehensive exploration of a particular entity such as an individual, group, locality, event, entity, or condition (Yin, 2018). This research method is extensive across disciplines, notably in fields such as the social sciences, education, health sectors, and business studies (Baxter & Jack, 2008). Although case studies typically utilize qualitative analytical procedures, researchers may also integrate quantitative methods (Yin, 1981).

Stake (Stake, 1995) assumed that a case study examines a confined or bounded system within its natural context. In this research, the empirical analysis focuses on a singular entity within an international manufacturing corporation, examining it through the lens of established operations research models (Voss, 2010).

The research adopts an evaluative, quantitative approach. Specifically, it utilizes dual questionnaire sets: the Manufacturing Strategy Index (MSI) and the Sense and Respond (S&R) approaches, with a predominant focus on S&R (Bradford & Florin, 2003). The S&R method incorporates various tools, including the Sustainable Competitive Advantage (SCA), Analytic Hierarchy Process (AHP), Critical Factor Indexes (CFI), and assessments of Technology, Knowledge, Ranking, and associated Risk Levels (Saaty, 2008).

The study employed face-to-face interviews to complement the questionnaires, allowing respondents who requested clarifications on queried factors (Qu & Dumay, 2011). The interviewees consisted of 3 high-level departmental managers, one a line manager and another senior staff member with over two decades of serving, reflecting the company's upper-echelon perspectives. According to Takala’s assumption, upper management possesses extensive insights into their organization's vision and strategic direction (Takala et al., 2013). Consequently, employing questionnaires and interviews yields a more accurate reflection of the organization's objectives and aspirations.

3.2 MSI Model Formulas

The MSI model leverages the Responsive, Agility, and Leanness (RAL) framework, as proposed by Takala and Rautiainen (2003), to identify the underlying nature of a company's chosen business strategy. The RAL model provides insights into how well an organization balances its responsiveness to changes, its agility in seizing opportunities, and its focus on lean operations. Equations (1) - (4) deliver the normalized value percentage for each component of the RAL model, respectively.

$$Q\% = \frac{Q}{Q + C + T} \tag{1}$$

$$C\% = \frac{C}{Q + C + T} \tag{2}$$

$$T\% = \frac{T}{Q + C + T} \tag{3}$$

$$F\% = \frac{Q}{Q + C + T + F} \tag{4}$$

Q = Quality; C = Cost; T = Time/delivery; F = Flexibility

Equations (5) - (7), assist in the MSI value computation, aiding in determining the company's strategic type and competitiveness level (Takala et al., 2013).

The MSI model for the prospector group:

$$MSI_p = 1 - \left(1 - Q\%^{\frac{1}{3}}\right) * (1 - 0.9 * T\%) * (1 - 0.9 * C\%) * F\%^{\frac{1}{3}} \tag{5}$$

The MSI model for the defender group:

$$MSI_d = 1 - \left(1 - C\%^{\frac{1}{3}}\right) * (1 - 0.9 * T\%) * (1 - 0.9 * Q\%) * F\%^{\frac{1}{3}} \tag{6}$$

The MSI model for the analyzer group:

$$MSI_a = 1 - (1 - F\%) * \{ABS[(0.95 * Q\% - 0.285) * (0.95 * T\% - 0.285) * (0.95 * C\% - 0.285)]\}^{\frac{1}{3}} \tag{7}$$

3.3 Sustainable Competitive Advantages (SCA)

Relational architecture, along with reputation, innovation, and strategic assets, forms the cornerstone of sustained competitive advantage within organizations(Kay, 1995). Building on this foundational concept, Kay has highlighted the significance of cultivating multi-party alliances and networks. Kay's insights are based on the resource-based theory of the firm, which underscores the role of an organization's unique capabilities and assets(Barney, 2001). These critical elements serve as critical drivers for competitive differentiation in both public and private sector firms (Hunt, 1997).

The essence of SCA lies in its ability to articulate the operational competitiveness of companies on a global scale, especially those encountering and adapting to crises (Liu, 2013). The SCA technique operates by analyzing if a company's resource allocation supports its operational strategy. Through specific mathematical models – the Mean Absolute Percentage Error (MAPE), the Root Means Squared Error (RMSE), and the Mean Absolute Deviation (MAD) – it becomes possible to determine the SCA risk levels that reflect the degree of alignment between resource allocation and operations strategy(Takala et al., 2013).

SCA risk levels offer a spectrum from 0 to 1 to evaluate this alignment, with values closer to 1 indicating a strong concordance between resources and strategy and denoting a high SCA(Liu & Liang, 2015). More specifically, figures equal to or greater than 0.97 are considered high, those between 0.93 and 0.97 signify a medium risk level, and values below 0.93 are categorized as low. Adding to this stratification, Liu and Liang (2015) set a distinct threshold, suggesting that an SCA risk level at or above 0.9 indicates notable alignment. The greater the SCA risk level, the more likely the operational strategy is sustainable. Alternatively, an SCA risk level nearing zero would warn of a potential disconnect, portending a strategy that may be inefficient due to misaligned resource deployment.

3.4 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), developed by Saaty in the early 1970s (Saaty, 2016), is a comprehensive decision-making tool that adeptly navigates through quantitative and qualitative factors, allowing for effective comparisons and decisions. Saaty introduced AHP to alleviate the complexity of decision-making processes (Saaty & Ozdemir, 2003), emphasizing a structured hierarchical approach that enables a more manageable analysis of factors. The AHP aims to offer a clear, efficient pathway for decision-making by grounding choices in empirical evidence and highlighting critical elements in decision scenarios (Dos Santos et al., 2019).

This methodology progresses through three sequential phases: breakdown of the problem, evaluation of elements, and amalgamation of priorities. The initial phase involves deconstructing the problem from a broad perspective down to more specific, manageable criteria (Saaty, 2008), ensuring an orderly and clear evaluation. Each hierarchical level is designed to deliver a focused viewpoint on the criteria, advancing from general to specific criteria, which aids in prioritizing relative to overall goals.

The AHP process unfolds in three stages:

- Breakdown of the problem: The complex problem is broken down into manageable sections, progressing from general criteria to detailed factors.
- Evaluation of elements: Decision-makers conduct pairwise comparisons of different criteria and sub-criteria, setting priorities on a scale from 1 to 9 to choose the optimal alternative.
- Amalgamation of priorities: The ultimate goal is to assign priorities to lower-level elements that accurately reflect their relative impact on the top-level hierarchy.

The numerical values of the pairwise comparison scale and its corresponding meaning are shown in Table 1.

Verbal Judgement	Numberic Value
Extremely Important	9
	8
Very Strongly More Important	7
	6
Strongly More Important	5
	4
Moderately More Important	3
	2
Equally Important	1

Table 2. Pairwise Comparison Scale (Source:(Saaty, 1980))

The Table 2 shows an Example to pairwise comparison between competitive priorities, each criteria needs to be evaluated against each other.

Cost	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Quality
Cost	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Time
Cost	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Flexibility
Quality	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Time
Quality	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Flexibility
Time	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Flexibility

Table 3. An example of pair-wise comparison of competitive priorities

At its core, the AHP methodology incorporates pairwise comparisons to rank priorities and distinguishes the best-suited alternatives, upheld by a discriminating comparison scale to ensure the integrity of these assessments (Belton & Gear, 1983). To maintain methodological reliability, the consistency ratio (CR) is monitored not to exceed 0.10, resulting in the robustness of the derived outcomes (Saaty & Ozdemir, 2003).

The inception of AHP has profoundly impacted organizational strategy and multifaceted decision-making frameworks, providing a systematic approach to dissecting complex issues into a structured hierarchical format (Buckley, 1985). This organization facilitates clarity for decision-makers and fosters transparent evaluation of decision criteria by juxtaposing them, thus illuminating the compromises between diverse objectives (Ishizaka & Labib, 2009).

3.5 Critical Factor Index (CFI)

The Critical Factor Index (CFI) method serves as an evaluative tool to identify essential attributes within a business process, as perceived by the organization's employees, customers, or business partners (Ranta & Takala, 2007). Building upon the CFI framework, Nadler, D., & Takala, J. (2008) developed the Balanced Critical Factor Index (BCFI) model, which calculates the variance in critical factors influencing organizational processes. To address the limitations inherent in the CFI and BCFI models, Liu & Takala (2012) proposed the Scaled Critical Factor Index (SCFI) model. This model ensures the reliability of outcomes, even with a constrained sample size. Following practical application and feedback, Vuoti, V. P., et al. (2014) introduced the New Scaled Critical Factor Index (NSCFI) model, enhancing the SCFI model's precision and stability. Fundamentally, these methodologies—CFI, BCFI, SCFI, and NSCFI—aim to determine resource allocation levels based on specific criteria methodically.

The following equations by utilized to analyze the raw data for calculating CFI, BCFI, SCFI, and NSCFI. Equations 8 through 11 are shared across the CFI, BCFI, and SCFI models. Nevertheless, for the NSCFI model, the calculation of the gap index and development index deviates, as demonstrated in equations 12 and 13, respectively. :

$$I_{Imp} = \frac{\bar{X}_{EP}}{10} \tag{8}$$

$$I_{Pef} = \frac{\bar{X}_{ER}}{10} \tag{9}$$

$$I_{Gap} = \left| \frac{\bar{X}_{EP} - \bar{X}_{ER}}{10} - 1 \right| \tag{10}$$

$$I_{Dep} = |(P_B - P_W) * 0.9 - 1| \tag{11}$$

$$I_{Gap'} = 2^{\frac{\bar{X}_{EP} - \bar{X}_{ER}}{10}} \tag{12}$$

$$I_{Dep'} = 2^{(P_B - P_W)} \tag{13}$$

$$Critical\ factor\ index\ (CFI) = \frac{S_{EP} * S_{ER}}{I_{Imp} * I_{Gap} * I_{Dep}} \tag{14}$$

$$Balanced\ scaled\ criteria\ factor\ index\ (BCFI) = \frac{S_{EP} * S_{ER} * I_{Pef}}{I_{Imp} * I_{Gap} * I_{Dep}} \tag{15}$$

$$Scaled\ Critical\ Factor\ Index\ (SCFI) =$$

$$\frac{\sqrt{\frac{1}{n} * \sum_{i=1}^{n}[experience(i) - 1]^2} * \sqrt{\frac{i}{n} * \sum_{i=1}^{n}[expectation(i) - 10]^2} * I_{Pef}}{I_{Imp} * I_{Gap} * I_{Dep}} \tag{16}$$

$$Normalized\ scaled\ critical\ factor\ index\ (NSCFI) =$$

$$\frac{\sqrt{\frac{1}{n} * \sum_{i=1}^{n}[experience(i)]^2} * \sqrt{\frac{i}{n} * \sum_{i=1}^{n}[expectation(i) - 11]^2} * I_{Pef}}{I_{Imp} * I_{Gap'} * I_{Dep'}} \tag{17}$$

Parameters

$\bar{X}_{EP} = Mean\ of\ Expectations$

$\bar{X}_{ER} = Mean\ of\ Experiences$

$S_{EP} = Standard\ deviation\ of\ Expectations$

$S_{ER} = Standard\ deviation\ of\ Experiences$

$P_B = Percentage\ of\ Better\ performance\ than\ Expected$

$P_W = Percentage\ of\ Worse\ performance\ than\ Expected$

$I_{Imp} = Importance\ index$

$I_{Pef} = Performance\ index$

$I_{Gap} = Gap\ index$

$I_{Dep} = Development\ index$

$I_{Gap'} = Gap\ index\ for\ NSCFI$

$I_{Dep'} = Development\ index\ for\ NSCFI$

4. EMPIRICAL RESEARCH ANALYSIS AND FINDINGS

The empirical research conducted in this study provides a detailed examination of Wärtsilä’s strategic direction, specifically within the Master Data Management (MDM) department. Through a combination of quantitative and qualitative data, the research explores how the department aligns with the broader corporate strategy while leveraging technologies such as Robotic Process Automation (RPA) to improve operational efficiency.
The analysis reveals the key operational dimensions—quality, cost, time, and flexibility—that drive decision-making within the department. Quality emerges as the highest priority, both in past operations and future strategic expectations, followed closely by flexibility. The research also identifies evolving priorities as the company continues its digital transformation, particularly with respect to improving time efficiency.

4.1 Background of Case Company

Established in 1834, Wärtsilä is one of the leading Finnish multinational firms known for its maritime-engine manufacturing. Over the years, Wärtsilä has built a business model based on smart technology and sustainable solutions to support global marine and energy markets. The company operates in about 200 locations spanning over eighty countries, and its services are dedicated to sustainable innovation that contributes significantly with data analytics advancements as well as operational efficiency, improving the environmental and economic performance of their customers' assets (Wärtsilä Corporation, 2020). "Wärtsilä prioritizes technology-driven innovation as a means to fulfill its ambition, and the strategy includes clear recognition of the role process automation has in enabling new technology solutions,” says Nishant Redekar, Process Automation Solutions Architect at Wärtsilä.
For a global group such as Wärtsilä, the rise of new demands in this 'digital time' goes without saying (Schwab, 2017). One of the key elements in this transformation is implementing Robotic Process Automation (RPA). Implementing RPA not only means technical integration but also a change in culture where automation becomes part of the organizational DNA. This may involve human resources and process management to ensure

that automation becomes institutionally embedded in the organization (Willcocks et al., 2015). The partnership with UiPath in 2016 was an important milestone for the automation of essential business processes, which has led to subsequent efforts at even greater levels (Tripathi, 2018). Wärtsilä has automated over 400 processes with more than 100 citizen developers involved in these initiatives, emphasizing the importance of workforce engagement. In 2017, Wärtsilä launched a Center of Excellence for RPA, training over 900 employees in RPA technologies, showcasing its commitment to building an RPA-skilled workforce (Wärtsilä Corporation, 2019). This move allows departments, such as maintenance and critical data management, to develop and implement their own RPA solutions.

Wärtsilä is also part of a broader strategic transformation toward global decarbonization. In 2022, the company established the Sustainable Technology Hub (STH) in Vaasa, Finland, and closed its four-stroke engine manufacturing plant in Trieste, Italy. Operations will be consolidated at the STH, leading to estimated annual savings of around €35 million by 2025 (Wärtsilä Corporation, 2022). The STH itself is designed as a "factory of the future," with flexible manufacturing systems and robotics that enable it to respond quickly to market changes while maintaining operational efficiency. Data analytics and digital twins are also central to how the STH operates, transforming data into actionable insights that unlock new business opportunities. Since partnering with UiPath in 2016, Wärtsilä's transformation strategy has focused heavily on automation. While some progress has been made in building automation systems from scratch, the company has paid limited attention to upgrading traditional automation systems. This gap presents an opportunity for departments like Master Data Management (MDM) to reassess their strategies and consider RPA as a strategic tool.

4.2 Target Department

4.2.1 Master Data Management (MDM)

In the dynamic operations of businesses, master data emerges as a crucial factor, encapsulating key information related to customers, products, workforce, materials, and

vendors that drive the daily functions of a company. This asset, mainly non-transactional, nevertheless plays an integral role in transactional processes and operational efficiency, signifying its expansive impact across the corporate structure(Pansara, 2021).
The realm of Master Data Management (MDM) offers a robust framework that encompasses processes, governance, policies, and standards. These are unified through designated tools to ensure consistent management and definition of an enterprise's critical data, aiming to maintain a singular, trustworthy data source (Hubert Ofner et al., 2013). Within MDM, systematic procedures are critical, such as the identification and purging of duplicate entries to enhance database efficiency and the implementation of uniform data frameworks that bolster accuracy(Pala, 2023). Beyond these, specified rules are enforced to maintain data integrity, effectively preventing inaccurate data entries and reinforcing the overarching structure of MDM.
Wärtsilä's approach to MDM is exemplified through its Shared Service Centre in Vaasa, Finland, which showcases a model of synergy between the corporate sector and the service center. The clear definition of roles and responsibilities within this collaboration exemplifies how an optimized, cohesive data management process can be achieved.
The whole MMD is divided into five departments, and the specific structure is shown in Figure 8, which is a parallel structure between departments and can effectively achieve cross-departmental coordination and cooperation.

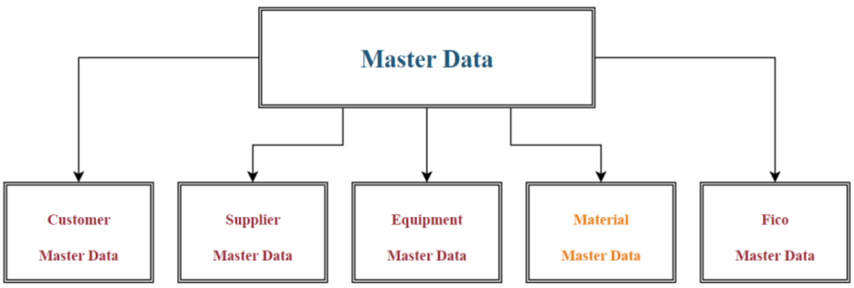


Figure 8. The Master Data Management Structure Charts

The Master Data Management (MDM) department offers a comprehensive suite of services, segmented into four primary areas: Data Maintenance, Mergers & Acquisitions

Support, Data Governance & Quality, and Solution Development. Each category encompasses various sub-services, detailed effectively in Figure 6. According to the company's statistics, the entire MMD department handles 278,000 service requests per year, serves more than 5,000 clients, and serves 125 companies in 85 countries around the world. This data underscores MMD's pivotal role in supporting the organization's global operations and its substantial impact on the company's data management capabilities.

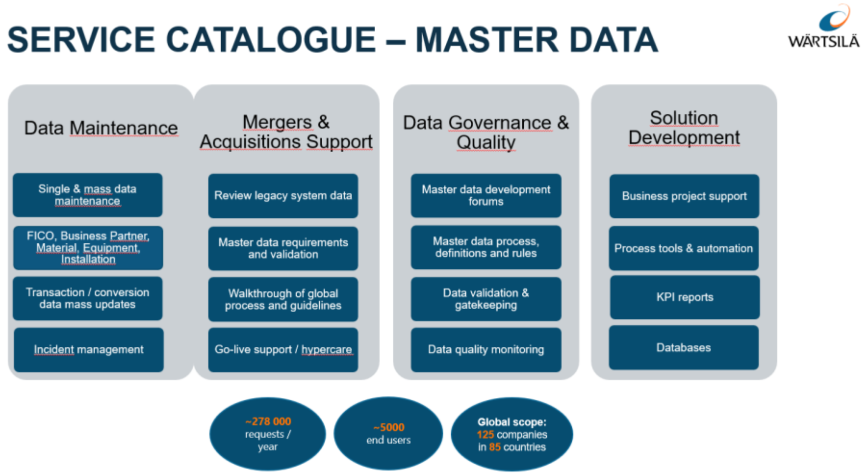


Figure 9. Master Data "Service Catalogue" (Source:(*Master Data Management (2024)*, n.d.)

4.2.2 Material Master Data (MMD)

The Material Master Data serves as a critical data repository within an organization, cataloging exhaustive details on the materials that underpin every aspect of the business lifecycle, from design and procurement to manufacturing, storage, and sales. Importantly, this repository encompasses not only physical goods but also intangible ones, such as services. This rich tapestry of data proves to be a linchpin for several SAP modules, underpinning functionalities in Warehouse Management (WM), Inventory Management (IM), Production Planning (PP), Quality Management (QM), and Sales and Distribution (SD), thereby streamlining core business operations (Gupta & Kohli, 2006).

To further refine data governance, Material Master Data is dichotomized into Global and Local data classifications. Global Data, categories that encapsulate foundational elements such as Basic Data 1 and Basic Data 2 are curated by Global Data Maintainers (GDM). In contrast, Local Data, which includes specific details about plant configurations, storage locales, and sales organizational frameworks, is entrusted to Local Data Maintainers (LDM).

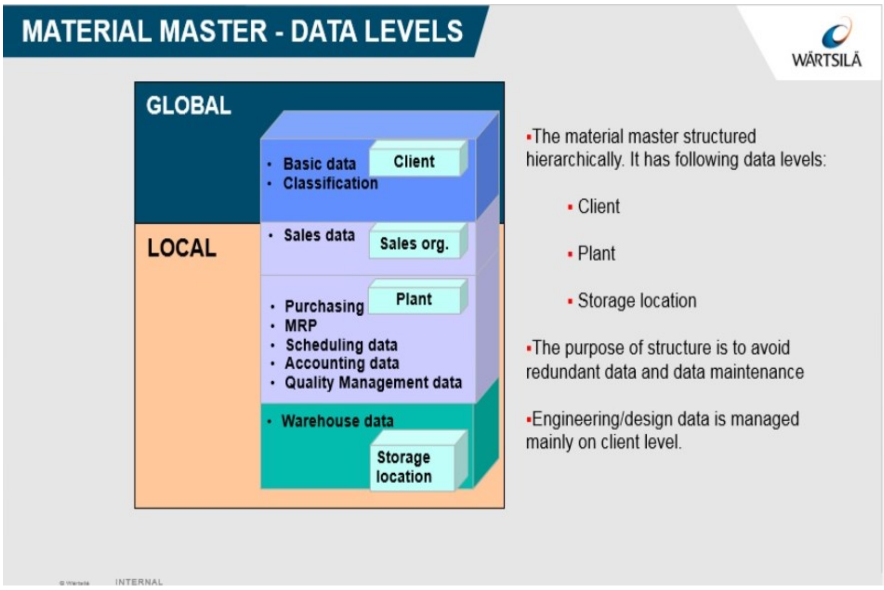


Figure 10. Material Master Data "Data structure" (Source: (*Master Data Management (2024)*, n.d.)

This Data structured separation ensures that data meets global consistency standards while also allowing for the adaptive, site-specific nuances managed by local expertise (Otto & Hüner, 2012).

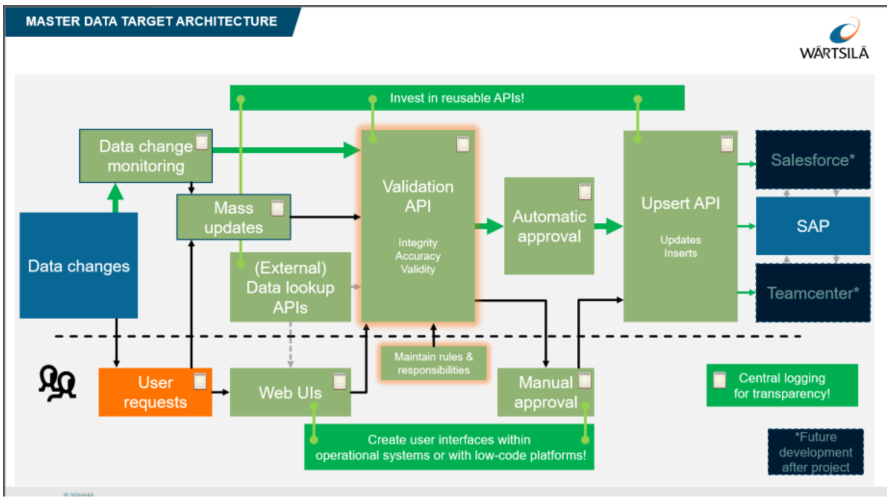


Figure 11. Material Master Data "Target Architecture" (Source: (*Master Data Management (2024)*, n.d.)

Figure 11 delineates the operational framework and processes within the Material Master Data (MMD) department. The workflow initiates when a user submits a service request, which triggers data modifications or batch updates within MMD. These updates undergo an automated approval process facilitated by an Application Programming Interface (API). Subsequently, the approved changes are implemented across various platforms, including SAP, Salesforce, and Teamcenter, via the Upsert API. This integration enables the seamless replacement of terminal data, culminating in a fully automated operation.

4.3 The Critical Factors

The analysis of Material Master Data (MMD) through the lens of the Management Strategy Index (MSI) questionnaire offers a fascinating insight into the organizational priorities concerning key operational dimensions: cost, quality, time, and flexibility.

The cost component encompasses both fixed and variable expenses, including management salaries, software licensing fees and so on. This dual categorization ensures a comprehensive understanding of the financial implications of implementing automation within an organization.

The dimension of quality pertains to the precision of data handling within automated systems. In the context of this study, it focuses on ensuring that operations such as data modification, addition, and deletion are executed without errors. Additionally, the stability of the automated process is critical, with the expectation that system operations proceed smoothly with minimal or no manual intervention.

Time refers to the duration required to complete a full cycle of business data modifications. This metric is essential in evaluating the efficiency gains achieved through automation by measuring how quickly operations are conducted.

Lastly, flexibility assesses the extent to which the automation system affects the existing Business Process Management (BPM) framework. It also evaluates the system's potential for future scalability, including its ability to integrate with other software systems. Ideally, automation should have a minimal impact on BPM processes and possess the capability to undergo swift upgrades, ensuring the system remains adaptable to future technological developments.

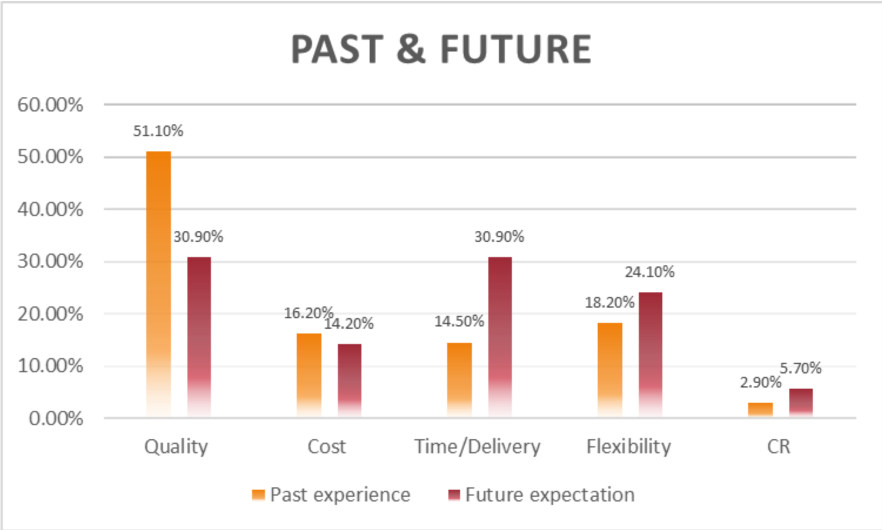


Figure 12. AHP calculated by online calculation – MMD
(https://bpmsg.com/ahp/ahp-calc.php?n=3&t=AHP+priorities&c[0]=Crit-1&c[1]=Crit-2&c[2]=Crit-3)

The outcomes derived from this survey underscore a predominant emphasis on quality as the quintessential driver of the organization's past experience, capturing an overwhelming weight of 51.1%. This is followed by the dimension of flexibility, standing at 18.2%, positioning it as the second-highest priority. Conversely, cost and time are attributed with comparatively lower weights, 16.2%, and 14.2% respectively, with time marked as the least critical, albeit not drastically trailing behind the cost.

As the organization looks towards the future, there emerges a striking consistency in the prioritization of quality, which although down to 30.9%, is still the heaviest. Intriguingly, the anticipation highlights an increment in the significance accorded to time, projected at 14.5% reach to 30.9% as same as quality, hinting at the MMD's strategic shift to enhance time efficiency. Simultaneously, the precedence of flexibility experiences a repositioning, elevating it to the third rank, thereby indicating an evolving landscape of operational priorities for the future. This reordering of priorities from experience to future expectations, albeit distinct, is validated by a consistency ratio below 10%, underscoring the reliability of the findings and the coherence in the comparative analysis.

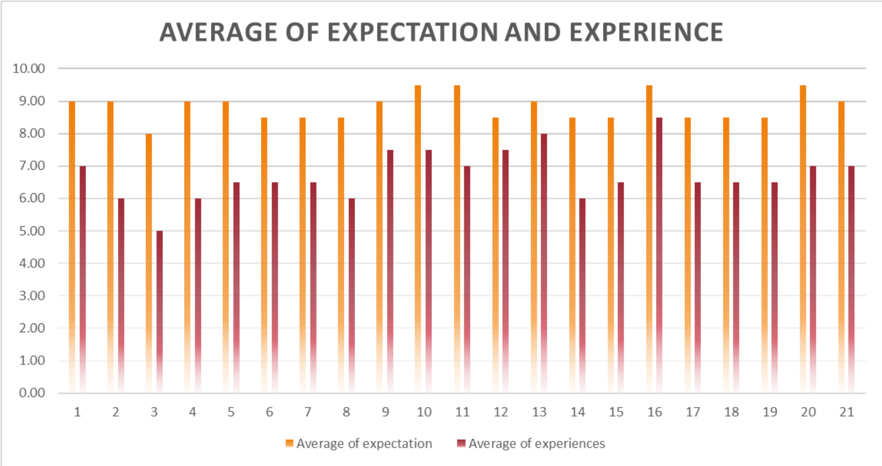


Figure 13. Average of Expectation vs Experience - MMD

Figure 13 it can be noticed that the case company have higher expectation than experience for all the 21 attributes (Appendix 2.) of resource inputs in multi-criteria operations strategy. There's an evident pattern where the company sets the bar high for itself, with expectations ranging ambitiously between 8.0 to 10.0. However, reality paints a different picture, with actual experiences spanning a wider, yet notably lower, range of 5.0 to 9.0. This gap is especially prominent for attributes 2, 3, and 4, where the difference hits a solid three points, indicating that the company might not be hitting its lofty targets in these areas as well as it hoped.

On the flip side, when we zoom in on areas dealing with the company's management and operational standards—specifically, attributes 12, 13, and 16, which focus on leadership and management systems, quality control, and data security, there's a much closer match between expectations and reality, separated only by a slim margin of one point. This smaller gap suggests that people working closely with these aspects of the company, due to their hands-on role in making key decisions and their deep familiarity with the company's inner workings, might have a more grounded view of what's achievable.

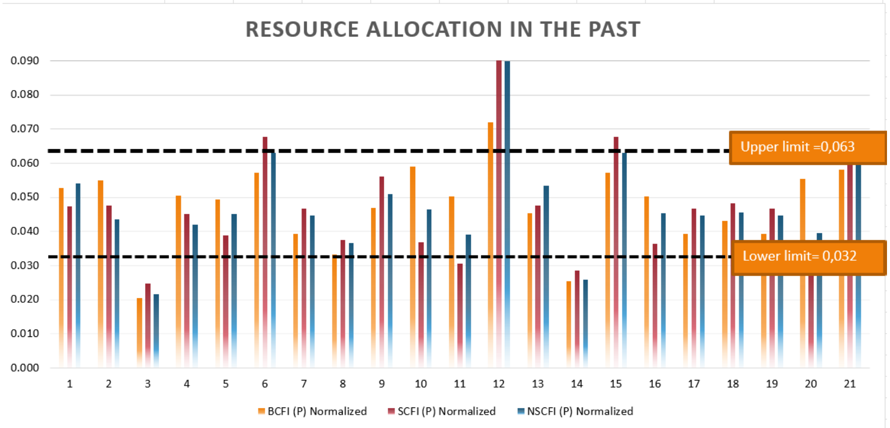


Figure 14. Resource allocation in the Past - MMD

Figure 14 offers a potent insight into the historical dispersal of the same resources, reflective of the organization's strategic undertakings. The demarcation of lower and upper bounds of 0.032 and 0.063, respectively, establishes a spectrum of resource allocation. Within this interval, attributes denote balanced resource dispersion. However, attributes flanking this interval denote critical resource territories inferring either excessive resource saturation or resource scarcity.

The BCFI Model unfolds its assessment, diagnosing three domains as under-resourced, a majority 17 as equably resourced, and a solitary domain as over-resourced. In comparison, the SCFI Model sketches a more radical posture, highlighting four domains each as under-resourced and over-resourced. The NSCFI Model, on the contrary, projects a more favorable vista, identifying merely two domains as under-resourced and one domain as over-resourced.

Despite the diverse conclusions drawn by these models, there is concurrence in identifying Parameters 3, 12, and 14—corresponding to "Communication between different departments and hierarchy levels," "Leadership and management systems of the company," and "Well defined responsibilities and tasks for each operation"—as focal points of organizational challenge. Improvement strategies for MMD could encompass resource reallocation to reduce processing time in these areas, thereby addressing their under-resourced status. On the other side of the spectrum, it appears that the organization has excessively prioritized management performance, a situation that requires rectification to achieve optimal resource distribution and organizational efficiency.

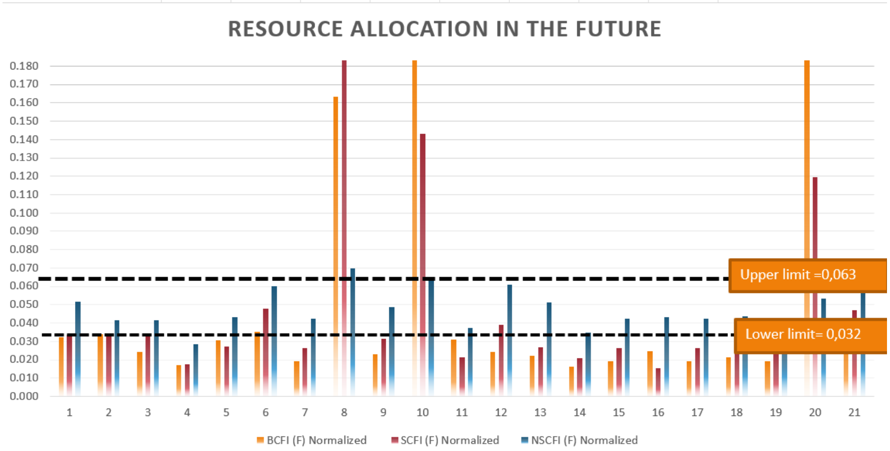


Figure 15. Resource allocation in the Future – MMD

In the analytical progression to the future, Figure 14 eloquently portrays the prospective dynamism accompanying resource allocation, as scrutinized through the lens of the BCFI model. This forward-looking evaluation markedly accentuates a deterioration in resource equilibrium. Where once 14 attributes enjoyed a balanced status, a concerning shift propels the majority into the realm of being under-resourced. A stark contrast is notably observed concerning Attribute 12, "Leadership and management systems of the company," which undergoes a drastic reversal from being significantly over-resourced to severely under-resourced.

Parallel to this, the SCFI model reveals a dwindling congregation of balanced attributes in the horizon of the future. Illustratively, a mere handful of attributes—1, 2, 3, 6, 12 and 21—remain within the sustainable confines of the lower and upper limits. In stark contrast, the New Strategic Critical Factor Index (NSCFI) paints a slightly more optimistic picture regarding the numerical count of balanced attributes mirroring, or potentially surpassing, their past counterparts. Yet, the composition of these equilibrated attributes undergoes a transformation. This confluence of insights derives a collective foreboding amongst the MMD respondents towards the organization's forthcoming resource allocation efficiency. Particularly, burgeoning concerns are levitated surrounding leadership and management dynamics, alongside the efficacy of process workflows and the strategic leverage of knowledge and technology.

BCFI(P)	BCFI(F)	Trend	SCFI(P)	SCFI(F)	Trend	NSCFI (P)	NSCFI (F)	Trend
Balance	Balance	Same	Balance	Balance	Same	Balance	Balance	Same
Balance	Balance	Same	Balance	Balance	Same	Balance	Balance	Same
Under	Under	Worse	Under	Balance	Better	Under	Balance	Better
Balance	Under	Worse	Balance	Under	Worse	Balance	Under	Worse
Balance	Under	Worse	Balance	Under	Worse	Balance	Balance	Same
Balance	Balance	Same	Over	Balance	Better	Over	Balance	Better
Balance	Under	Worse	Balance	Under	Worse	Balance	Balance	Same
Balance	Over	Worse	Balance	Over	Worse	Balance	Over	Worse
Balance	Under	Worse	Balance	Under	Worse	Balance	Balance	Same
Balance	Over	Worse	Balance	Over	Worse	Balance	Balance	Same
Balance	Under	Worse	Under	Under	Worse	Balance	Balance	Same
Over	Under	180 degree reversed	Over	Balance	Better	Over	Balance	Better
Balance	Under	Worse	Balance	Under	Worse	Balance	Balance	Better
Under	Under	Worse	Under	Under	Worse	Under	Balance	Better
Balance	Under	Worse	Over	Under	180 degree reversed	Over	Balance	Better
Balance	Under	Worse	Balance	Under	Worse	Balance	Balance	Same
Balance	Under	Worse	Balance	Under	Worse	Balance	Balance	Same
Balance	Under	Worse	Balance	Under	Worse	Balance	Balance	Same
Balance	Under	Worse	Balance	Under	Worse	Balance	Balance	Same
Balance	Over	Worse	Under	Over	180 degree reversed	Balance	Balance	Same
Balance	Balance	Same	Over	Balance	Better	Balance	Balance	Same

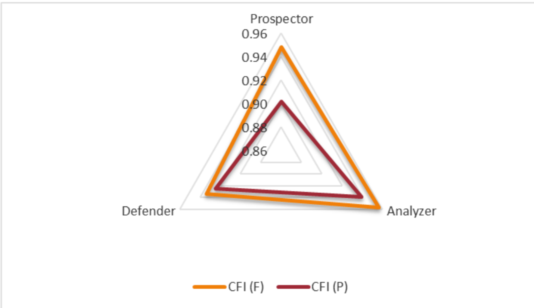
Table 4. Comparison between BCFI, SCFI, NSCFI – MMD

The insights provided by Table 4 serve to thoroughly analyze the predicted trends in resource allocation. Within the BCFI lens, a more challenging future is revealed—an anticipated decline in 16 attributes, a reversal in one, and balance preserved in merely four. Contrastingly, the SCFI model uncovers 13 attributes with a potentially negative trajectory, two exhibiting an unexpected turnaround, and an encouraging lift in four. When viewed through the NSCFI model, the landscape is most favorable—highlighting ascension in six attributes, steadiness in a notable 13, and a potential decline in just two. This implies encouraging future growth in almost half of the attributes analyzed through the NSCFI model.

The sobering projections of the BCFI model paint a less than ideal picture of circumstances at MMD, suggesting that the company's future will be significantly influenced by its hierarchical management structure at the group level. This underscores the need for greater autonomy within its subunits and the ability to shape their own narratives, perhaps pointing to variable real-world scenarios in the future.

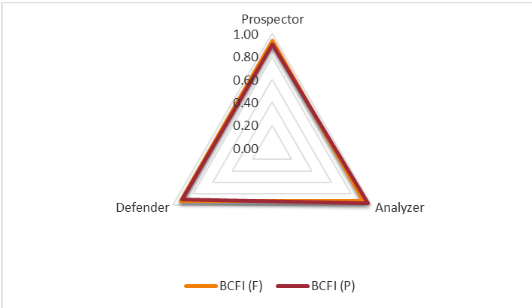
Unlike the BCFI model's predictions, the winds of the future seem more favorable according to the NSCFI model. The NSCFI model's superior capacity in accurately reflecting conditions of resource distribution (Liu & Liang, 2015). So, despite the disparities in outlook, these models collectively provide MMD with a plan for strategic adaptation and recalibration in their resource allocation strategies.

Feedback from MMD has highlighted a preference for the NSCFI model over the BCFI and SCFI models. The management group believes that the NSCFI model more accurately captures the current operational reality. This insight underscores the importance of developing a strategic plan tailored to enhance any underperforming attributes within the department. Such careful strategic planning is essential for improving resource allocation efficiency and the competitive edge.



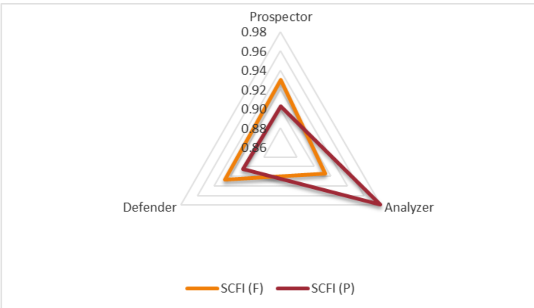
MSI values				
CFI	Prospector	Analyzer	Defender	Reactor
PAST	0.90	0.94	0.92	0.91
FUTURE	0.95	0.96	0.93	0.94

MSI competitiveness using CFI



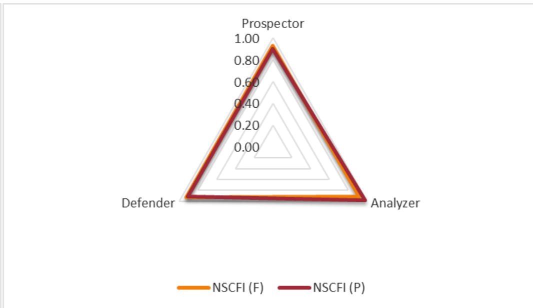
MSI values				
BCFI	Prospector	Analyzer	Defender	Reactor
PAST	0.91	0.97	0.90	0.91
FUTURE	0.94	0.92	0.93	0.93

MSI competitiveness using BCFI



MSI values				
SCFI	Prospector	Analyzer	Defender	Reactor
PAST	0.90	0.98	0.91	0.90
FUTURE	0.93	0.91	0.93	0.93

MSI competitiveness using SCFI



MSI values				
NSCFI	Prospector	Analyzer	Defender	Reactor
PAST	0.90	0.99	0.91	0.90
FUTURE	0.91	0.99	0.91	0.91

MSI competitiveness using NSCFI

Figure 16. MSI competitiveness using CFI, BCFI, SCFI and NSCFI - MMD

Figure 16 offers a comparative analysis of how the CFI, BCFI, SCFI, and NSCFI models affect MSI competitiveness over time. This analysis is framed using the MSI triangle (RAL model), which distinguishes between past performance (represented by a red triangle) and future expectations (represented by a orange triangle). The positions and shapes of these triangles are determined by MSI values associated with three strategic types: prospector, analyzer, and defender. As Takala et al. (2013) suggest, the closer these MSI values are to 1, the more closely a company's strategy aligns with its intended strategic type. This alignment is crucial for strategic coherence and the formulation of effective future strategies, emphasizing the critical role of model selection in reflecting a company's strategic positioning accurately.

As can be seen from Figure 8, the MSI values for analyzer are high both in the past (values ranging from 0.94 to 0.99) and in the future (values ranging from 0.91 to 0.99). The scenario of the MMD maintaining its CFI within the Analyzer strategy range, while its BCFI and SCFI transition from Analyzer to a mixture of Prospector, Defender, and Reactor, and the NSFCI remains steadfast as an Analyzer, presents a complex strategic landscape.

The unchanged CFI model suggests that at the highest level, the department overarching corporate strategy remains committed to balancing between innovation and operational efficiency.

The shift in the BCFI to a Prospector strategy signals a desire to revamp the department’s competitive edge in the business domain through innovation, exploration, and risk-taking. This change shows an aspiration to move away from purely balancing innovation with efficiency, towards a more aggressive pursuit of new products and market opportunities. The SCFI’s movement towards not just a Prospector but also incorporating elements of Defender and Reactor strategies reflects a more nuanced approach to supply chain management. Meaning this is not only looking at innovation (Prospector) but is also simultaneously focused on improving the efficiency of existing operations (Defender) and remaining adaptive to unexpected changes (Reactor).

The strategic complexity faced by MMD, as an individual department within a vast corporate group, reflects a challenging twofold aspect of strategic management. On one hand, it necessitates the consideration of the department's own developmental trajectory which fuels its quest for progress and innovation. On the other hand, it operates within the confines of the larger group’s mandates, shaping a dynamic where continuous, multidimensional self-adjustment is essential. This scenario demands that MMD harmonizes its aspirations with the predetermined strategic contours of the conglomerate. As a result, MMD's strategic disposition is one characterized by a delicate balance—striving for autonomous growth while remaining in alignment with the broader corporate environment’s expectations and restrictions. This ability to adapt and evolve within a larger context is pivotal to the overall coherence and efficiency of the conglomerate’s operations.

The NSCFI has strategically decided to maintain its role as an Analyzer. This choice suggests that at the conglomerate level, there's a strong focus on balancing operational efficiency with a willingness to embrace innovation. This balance is possibly influenced by the need to navigate complex regulatory environments, adapt to market fluctuations, or manage logistical challenges. Such circumstances make adopting a middle-ground strategy not just sensible but sometimes essential for operations within the Wärtsilä group. MMD's top executives confirm that the Analyzer model perfectly reflects their operational strategy. This strategy is firmly focused on quality and timeliness, demonstrating a clear commitment to these core aspects.

	Normalized criteria weight				MSI values			Measures of SCA risk level		
	Q	C	T	F	Prospector	Analyzer	Defender	MAPE	RMSE	MAD
P-MSI	0.62	0.20	0.18	0.18	0.94	0.88	0.91			
F-MSI	0.41	0.19	0.41	0.24	0.91	0.92	0.89			
P-CFI	0.23	0.51	0.26	0.23	0.90	0.94	0.92	0.90	0.93	0.95
F-CFI	0.57	0.30	0.14	0.10	0.95	0.96	0.93	0.99	0.99	1.00
P-BCFI	0.37	0.36	0.28	0.28	0.91	0.97	0.90	0.86	0.91	0.93
F-BCFI	0.54	0.32	0.14	0.14	0.94	0.92	0.93	0.97	0.98	0.98
P-SCFI	0.33	0.36	0.32	0.27	0.90	0.98	0.91	0.85	0.91	0.93
F-SCFI	0.43	0.38	0.19	0.15	0.93	0.91	0.93	0.96	0.97	0.98
P-NSCFI	0.34	0.36	0.30	0.27	0.90	0.99	0.91	0.83	0.90	0.92
F-NSCFI	0.36	0.34	0.30	0.24	0.91	0.99	0.91	0.93	0.95	0.96

Table 5. SCA calculations and MAPE, RMSE and MAD - MMD

To assess a company's strategic fit, the first step is to evaluate risk levels and resource allocation effectiveness (Takala et al. 2013). According to Table 5, the RMSE and MAD values are predominantly above 0.9, indicating a strong historical operational efficiency at MMD. In contrast, some MAPE values fall below 0.9, suggesting areas where resource allocation may not fully align with strategy. MMD has shown a preference for RMSE and MAD in measuring stability and performance, accepting the lesser accuracy of MAPE for its insights into fluctuation. The findings from Table 5 imply that MMD's historical strategies have been well-supported by resources, but they might need to adjust for future conditions. Thorough analysis of MMD's strategic trajectory is essential to address potential gaps in strategy-resource cohesion. Addressing these issues is crucial for maintaining MMD's competitive edge.

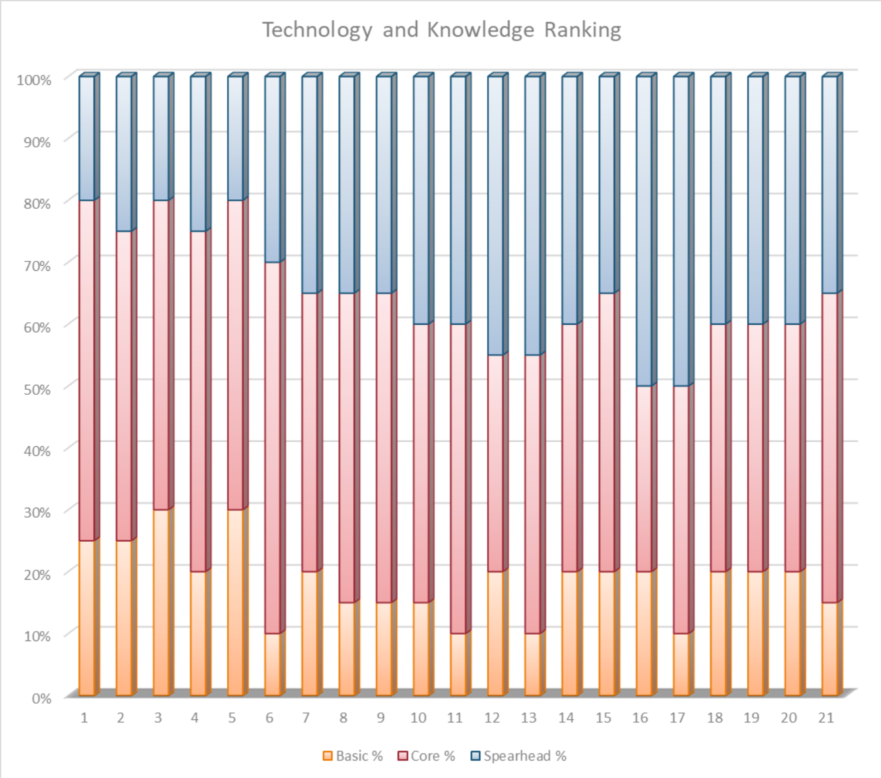


Figure 17. Ranking of Basic, Core, Spearhead Technology and Knowledge- MMD

Figure 17 provides a visual representation of MMD's strategic allocation of technological and knowledge resources across three distinct categories: basic, core, and spearhead. The distribution is numerically articulated as an average commitment of 18.57% to basic technology and knowledge (T&K), 45.95% to core T&K, and 35.48% to spearhead T&K. This allocation pattern indicates a deliberate prioritization, positioning core T&K as the fulcrum of MMD's innovation efforts, reflecting its central role in sustaining competitive advantage. Conversely, the comparative underweight given to basic T&K suggests a strategy that does not require a broad foundation of generalized technology and knowledge but rather, one that is honed for impactful differentiation in the marketplace. Within the core T&K spectrum, the majority of attributes are recognized as drivers of competitiveness.

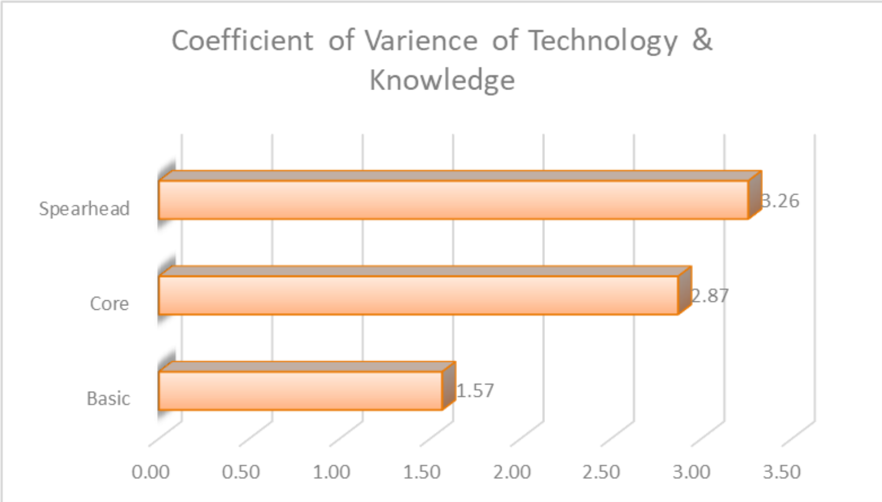


Figure 18. Coefficient of variance of Technology and Knowledge - MMD

Figure 18 presents an analytical exposition of the degree of consensus among department regarding the value they assign to different types of T&K. Within this graphical illustration, the coefficient of variance emerges as a pivotal statistical indicator, with its magnitude reflecting the extent of variation in responses: a larger coefficient signifies a broader dispersion in opinions, while a smaller coefficient denotes a narrower range, indicative of greater agreement. Scrutinizing the coefficients detailed in Figure 10 reveals that for basic, core, and spearhead T&K, these values are 1.57, 2.87, and 3.76, correspondingly. Such gradation not only demarcates an increasing disparity in viewpoints as one transitions from basic to spearhead technology but also underscores a pronounced uncertainty particularly associated with spearhead T&K. This disparity is indicative of the profound challenges faced by the department in integrating cutting-edge T&K into its operations, as divergent perspectives could potentially impede the strategic assimilation of these advanced technologies.

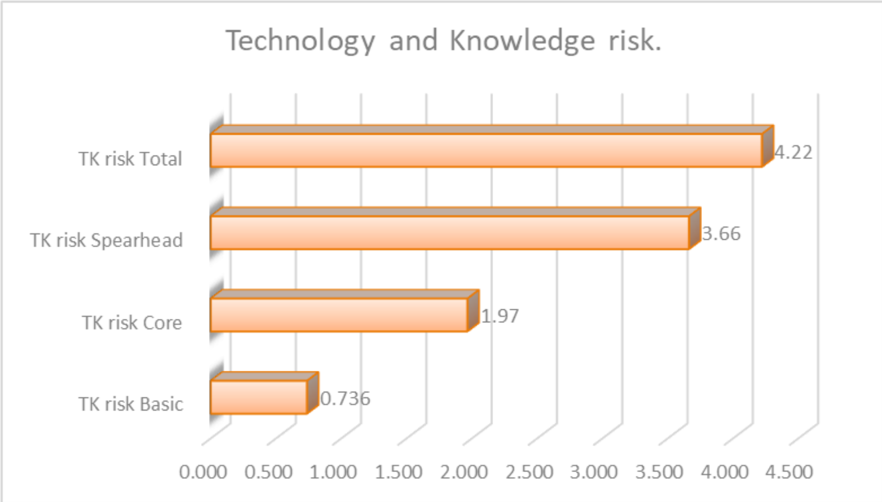


Figure 19. Technology and Knowledge Risk – MMD

Figure 19 thus lays bare the landscape of T&K risk levels across these segments, with an analytical lens focused on the coefficient of variation across 21 attributes to gauge respondent uncertainty regarding the proportional investments in basic, core, and spearhead T&K. The resultant risk metrics—0.736 for basic T&K, 1.97 for core T&K, and a notably higher 3.66 for spearhead T&K—unequivocally signal an escalating risk paradigm as one progresses towards the more avant-garde spearhead T&K. This pattern aligns with the strategic posture of an analyzer organization, which prudently navigates the innovation landscape, espousing market trends and breakthroughs without shouldering the frontline risks of innovation. In such a schema, it is inherently rational for higher risk quotients to be associated with spearhead T&K, mirroring MMD's strategic calibration and its consequent risk exposure in striving for future business triumphs amidst the fluctuating dynamics of market competitiveness and technological evolution.

4.4 Strategic Alignment and Future Implementation

After the analysis, department heads agree that the analyzer role fits their strategy well. Quality has been and will continue to be the most crucial factor. As the department responsible for generating and maintaining raw data, data quality is a top priority that safeguards the company's overall health by minimizing potential errors. In the future, timeliness will become the second priority, while the importance of flexibility will slightly diminish to third place. The ongoing digital transformation of the group demands that the department processes data more quickly and maintains future upgrade and iteration capabilities. Meanwhile, cost considerations fall under the broader scope of company-wide management and are therefore deemed the lowest priority for the department. Hence, MMD intends to continue emphasizing quality, time, flexibility, and cost in the coming years.

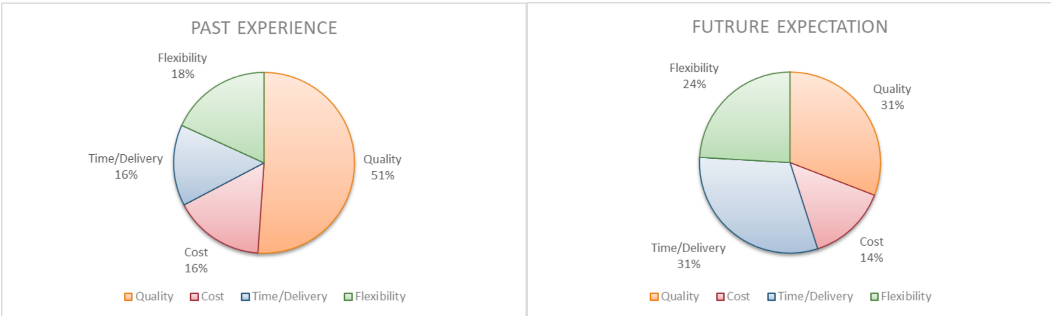


Figure 20. Percentage of Quality, Cost, Time, Flexibility for the MMD in Past and future

MMD believes that the NSCFI model, compared to the BCFI and SCFI models, better aligns with their circumstances by presenting the most optimistic projections. The department's development is seen as stable with expectations for continued or improved performance.

Based on SCA analysis, the MAD and possibly the RMSE methods are more effective for SCA risk identification than the MAPE method. The strategies of MMD have been comparatively sustainable in the past and are poised to improve even further in the future.

Regarding technology and knowledge management, basic and core technologies pose the least risk, whereas spearhead technology introduces the greatest risk and uncertainty. Feedback from the department confirms that the technology and knowledge management outcomes are well-suited to the current situation. The risk hierarchy of technology and knowledge is considered normal and fits the organization's posture of not prioritizing spearhead technology initially as MMD functions primarily as an analyzer. As such, the department plans to continue its analyst strategy while integrating core technologies like RPA (Robotic Process Automation), which will not diminish its competitive sustainability and aligns with future strategies.

Consequently, the next phase will involve implementing RPA within a specific business process, replacing the existing automation systems. This implementation will be evaluated across four dimensions: quality, time, flexibility, and cost, to ensure alignment with departmental strategies.

5. IMPLEMENTATION

In this chapter, our goal is to transition the existing setup into a system that utilizes Robotic Process Automation (RPA). The development of RPA in the company's business division is executed in an agile manner, actively involving employees from the very beginning and following a bottom-up business process approach. The RPA delivery organization is divided into three key roles: the business user (or citizen developer), the RPA manager, and the central programming team.

The business users—employees whose primary responsibilities lie outside of IT, yet they stand to benefit significantly from RPA's ability to reduce manual workload and increase efficiency (DashDevs, 2023). These employees can also evolve into citizen developers, a role that involves creating simple, minimum-viable RPA solutions, bridging the gap between technical development and business processes (phoenixNAP, 2023). RPA managers play a crucial role in overseeing the entire automation lifecycle, from assessing automation feasibility to managing its deployment into production environments. They ensure that processes are appropriately selected and aligned with organizational goals, coordinating between various teams to optimize automation implementation (DashDevs, 2023; phoenixNAP, 2023). Once an RPA solution is approved, a central programming team is tasked with its development and ongoing maintenance, ensuring that the automation remains functional and adaptable to changes in the system (Microsoft Power Automate, 2023).

The typical RPA application process is as follows: A business user first identifies a process for automation, which should have the potential to save time, improve quality, or speed up operations, and then creates an initial version of the RPA. At the same time, the process is documented in detailed, step-by-step instructions. Following this, the RPA manager assesses whether the RPA is functional and forwards it to the central RPA programming team for implementation in the production environment. There, the RPA undergoes piloting and quality assurance to ensure it operates as intended in the production setting and is integrated into the server's infrastructure. For this study, the RPA was developed starting from the citizen developer stage. Since this is still at the experimental phase, the RPA is limited to the target department.

5.1 Current Automation Process

The current business automation process at Wärtsilä MMD involves leveraging significant software such as Toad and Winshuttle. These tools are used to manage and transfer large volumes of data efficiently between various systems, specifically focusing on SQL-based operations and ERP data management. This section outlines the existing automation process, highlighting the tools used, their functionalities, and the challenges faced due to the geographical separation of servers and the inherent uncertainties in the process.

SAP, or Systems, Applications, and Products in Data Processing, is an enterprise resource planning (ERP) software that serves as a central platform for managing various business operations, including finance, production, sales, and human resources. Originally developed in the 1970s, SAP has grown to become one of the most widely implemented ERP systems globally, known for its capacity to integrate and streamline complex workflows across an organization’s departments (Davenport, 1998). By consolidating critical data into a unified platform, SAP enables real-time information flow and improves decision-making, fostering operational efficiency and alignment with organizational goals (Al-Mashari et al., 2003).

Toad is a comprehensive database management tool used for SQL-based operations on various data systems(Sun & Larry, 2014). Toad establishes a connection with the Wärtsilä database to extract specific data required for the automation workflow. For instance, it filters Material Numbers (MN datasheet) necessitating classification and compiles this filtered data into an Excel file.

SAP Winshuttle, conversely, offers a powerful interface for transferring large volumes of ERP data efficiently (Goel et al., 2021). Notably, Winshuttle’s distinct advantage is its invasive data shuttle system between Excel and SAP, enhancing flexibility and winning efficiency in the data management process. Upon receiving the Excel file from Toad, Winshuttle processes the data by integrating it into SAP.

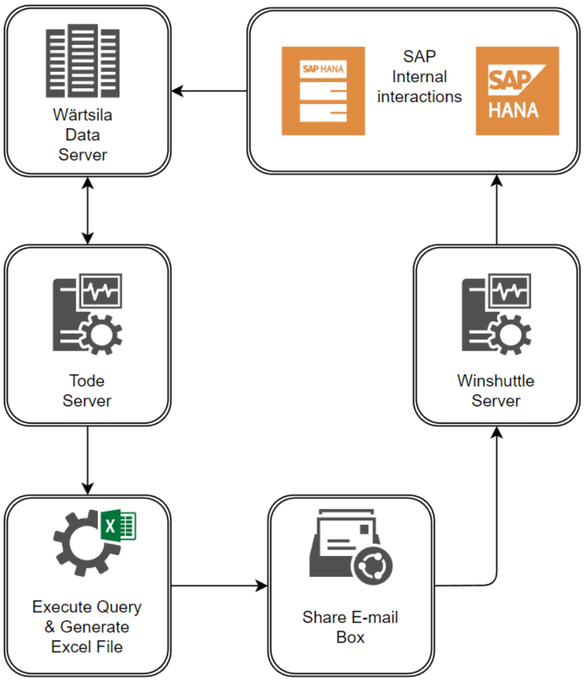


Figure 21. Original Automation Process

The business process leverages two distinct software systems hosted on servers in separate locations to automate data handling. Initially, Toad extracts the necessary data and forwards it to Winshuttle via email. Winshuttle then processes and integrates this data into SAP, completing the operation.

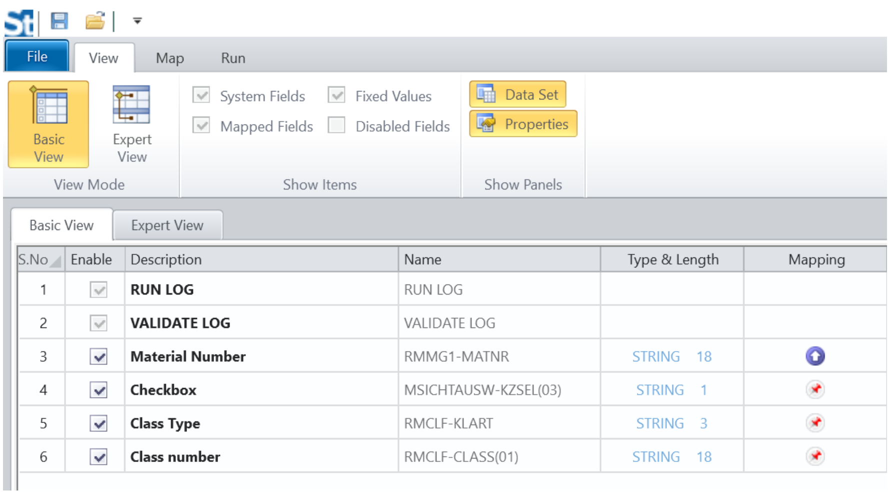


Figure 22. Winshuttle Automated Processes

Based on the existing business automation process, several challenges have been identified. The procedure incorporates two software programs with a consequential sequence of steps—specifically, reading data before modifying it, where the modifications can influence subsequent data retrieval—it is crucial to ensure that the database remains unwritable during the reading phase. Therefore, it is crucial to ensure that the database remains unwritable during the reading phase to maintain data integrity.
However, the deployment of the two software systems on servers situated in different geographical locations introduces uncertainties due to time zone differences, staffing, and network transmission variability. To maintain the integrity of the process, safeguards must be established to prevent database write operations during the data extraction phase. Moreover, acknowledgement of the inherent uncertainties necessitates robust protocols to mitigate potential disruptions due to the physical separation of the software systems and the fluctuating nature of network transmissions.

5.2 Plan for Implementation

In this section, the plan for implementing Robotic Process Automation (RPA) to enhance the existing business automation process will be outlined. The goal is to simulate the original process steps and repeat them efficiently using RPA, specifically UiPath, to improve data management and operational efficiency.
Simulating the original process steps and repeating them over and over again is a prerequisite for creating an RPA (Radke et al., 2020). For this case, by connecting to a database and emulating Toad software to selectively maintain data within the Wärtsilä database. A pivotal distinction from the afore mentioned automation system is the internal circulation of the process within UiPath, which negates the necessity for geographically distant transmission of Excel data files. Consequently, Excel files can be locally stored and directly accessed and read by the subsequent SAP module phase. UiPath's non-invasive nature allows for the use of batch T-codes within SAP software without requiring invasive SAP operations. This enhances flexibility and autonomy.
A detailed process flowchart is provided below:

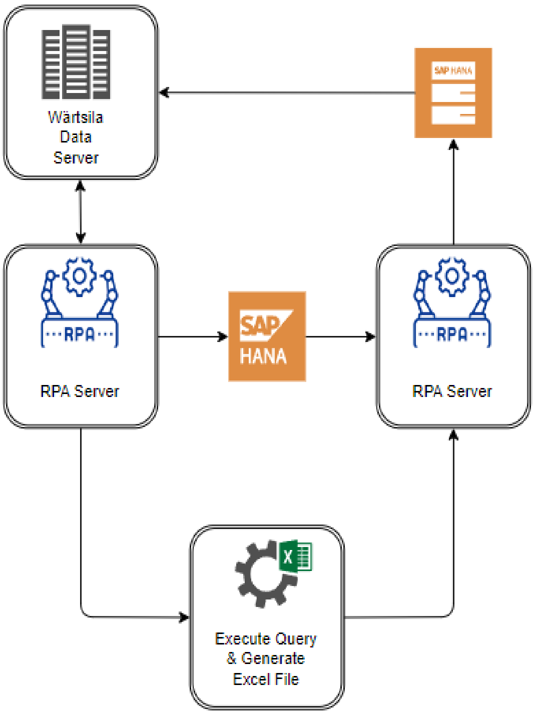


Figure 23. Uipath Automation Processes

(1) Database Connection:

The database and RPA connect directly via embedded API access. After inputting the database server address, username, and password, queries can be executed directly, filtering and saving required data locally.

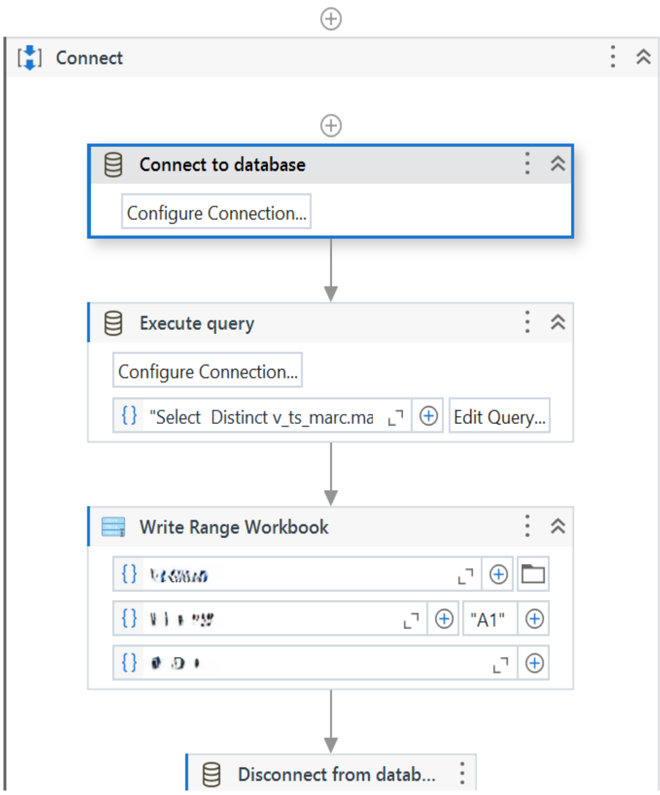


Figure 24. Uipath RPA Database Connection

By utilizing the database linking functionality of RPA, a direct link is established to the company's main database through a remote address. Then, Oracle's database language is employed in the 'Execute Query' section to filter out the relevant data required by the business flow. For this particular business flow, the needed information includes materials number in Plant Gls1 and Classification type 022 which missing WCH_Batch, after generating the Query, the RPA will save the Excel datasheets locally.

(2) SAP Link:

RPA features an embedded SAP login module. After locating the SAP software path and selecting the appropriate environment (e.g., "1.01 WE ECC Production (WEP)"), users can directly access the SAP system.

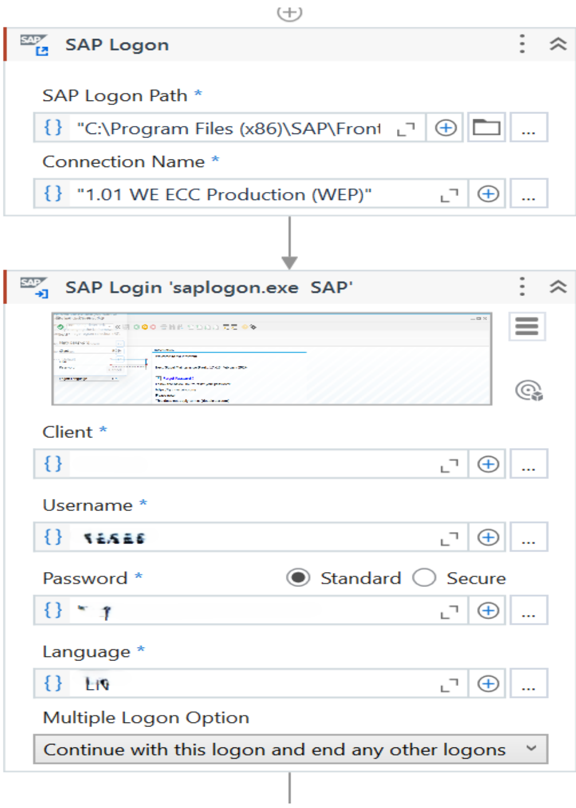


Figure 25. Uipath RPA SAP Link

First, the RPA automatically starts the SAP software by locating the SAP software address in the computer, and selects the 'WEP' environment in multiple runtime environments. Then, on the SAP login interface, it automatically inputs the username, password, and language to be used. If the same user is logged in concurrently, the user controlled by the RPA is prioritized, and other user sessions are simultaneously terminated.

(3) Batch Modification in SAP:

RPA enables batch modifications and additions within SAP primarily through screen capture, simulating human operation. Notably, RPA allows for batch processing T-codes, unlike the original automation system's restrictive single-material T-code approach.

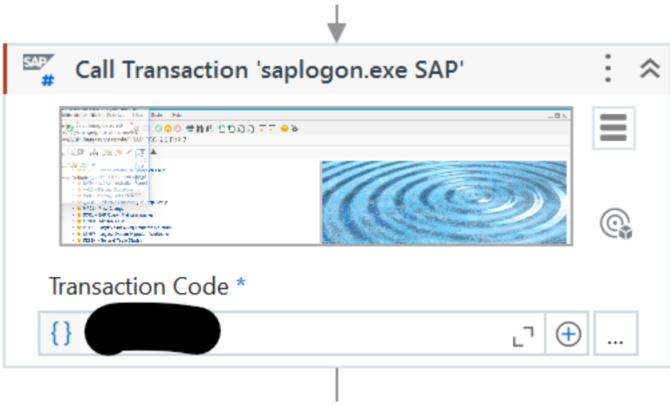


Figure 26. Uipath RPA Call Batch T-code

After using the batch processing SAP T-code, RPA can be configured to automatically enter classification type 022.

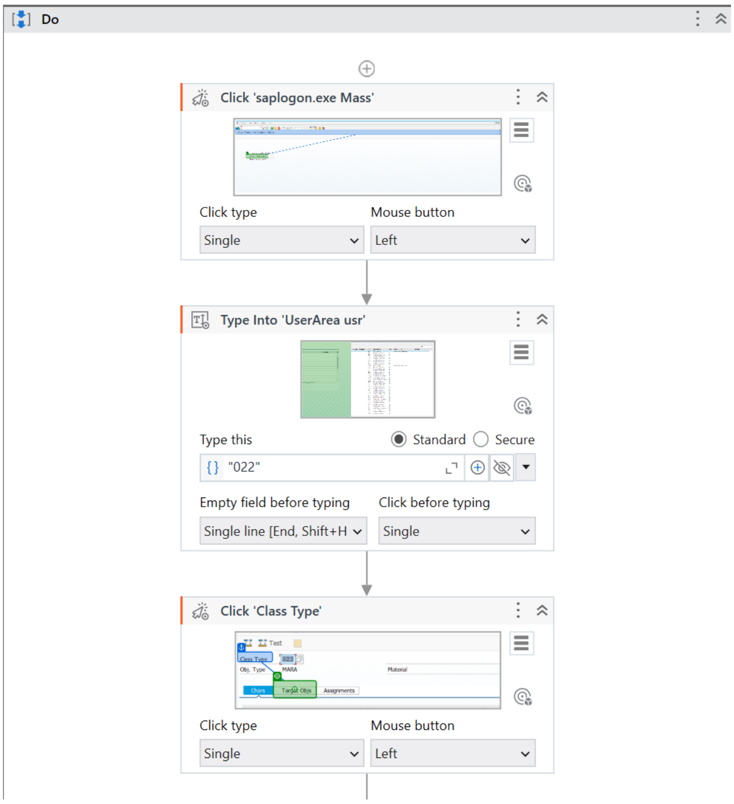


Figure 27. Uipath RPA Insert Type 022

Then, retrieve the previously stored Excel datasheets of material with missing WCH_Batch information locally, and automatically perform batch additions in SAP.

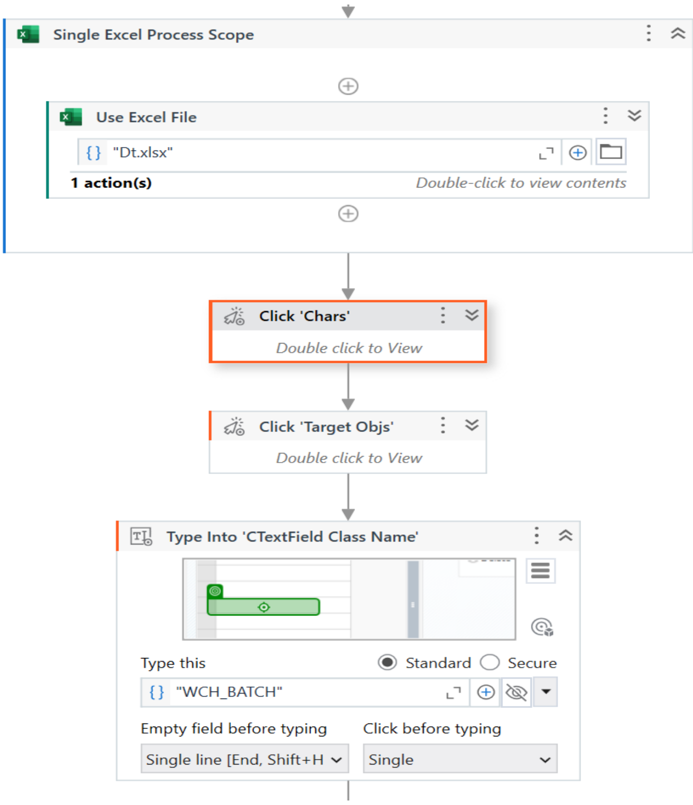


Figure 28. Uipath RPA Batch Modification

To compare these modes, two automation scenarios were designed within RPA's SAP processing module: 1) non-batch processing based on the original automation, and 2) batch processing using RPA. When using the original single-material T-code, data processing becomes linearization, leading to inefficiencies like false touches, lagging, and prolonged processing times. Conversely, RPA's batch processing capability significantly improves timeliness and reduces entry errors and lagging by handling data collectively.

In summary, the implementation plan for RPA involves simulating the original process steps within UiPath to enhance data management and operational efficiency. By eliminating the need for geographically distant data transmission and enabling batch processing within SAP, UiPath offers significant improvements in flexibility, autonomy, and overall process efficiency. This transformation aims to address the challenges of the current system and pave the way for a more streamlined and effective automation process.

5.3 Process Evaluation and Results

The assessment of RPA automation processes is rigorously conducted across four critical dimensions: cost, quality, time, and flexibility.

Cost: The RPA, developed using UiPath, incurs no additional costs for the department. On the contrary, it significantly reduces expenditure by decreasing server usage and eliminating the need for paid software like Toad and Winshuttle (6700€ per year), thereby lowering the department's operational costs.

Quality: The quality aspect of the RPA is twofold. Firstly, it involves the accuracy of data selection within the database. Secondly, it encompasses the success rate of data modifications in SAP. These components align with the original automation strategy while enhancing data quality. This improvement is attributed to the reduction of network instability and other uncertainties resulting from the transfer of Excel files between two software applications. Moreover, UiPath's non-invasive approach ensures the stability of the SAP system, further guaranteeing data integrity.

Time: In terms of time efficiency, the RPA employs batch modification T-codes in SAP, which replaces the previously automated, time-consuming, individual processing based on SAP RFC function modules. For example, updating data for 45 items previously required 7.5 minutes using the old method. With RPA, the same task now takes just 2 minutes. Given that this task is carried out daily, the significant cut in processing time substantially boosts overall work efficiency.

Flexibility: The UiPath platform provides a flexible environment for developing processes, along with a proactive approach to product evolution. This flexibility is crucial for customizing processes that can adapt to changing business requirements, while also ensuring they can be scaled and maintained with ease. Currently, Wärtsilä's RPA is in its third phase, which includes capabilities in the cloud, allowing for enhanced automation and the ability to scale up as needed. In addition, the company is building its own autonomous AI ecosystem, which will enable the automation of increasingly complex tasks and facilitate more sophisticated decision-making processes.

The integration of UiPath's RPA in MMD department has significantly enhanced efficiency, reducing operational costs by cutting server usage and the need for expensive software. This strategic move has improved the precision of data management and the effectiveness of SAP system modifications, largely due to UiPath's stable and non-invasive technology. Time management has been notably optimized, demonstrating RPA's capability to streamline tasks. UiPath's flexible platform allows for scalable process development, aligning with the department's evolving needs and ensuring maintainability. These results highlight the considerable advantages of RPA adoption, underscoring its effectiveness in boosting operational efficiency, data quality, and system stability which fully match the MMD future operation strategy and enable the department to be better equipped to meet future operational challenges.

6. DISCUSSION AND CONCLUSION

The integration of Robotic Process Automation (RPA) within Wärtsilä's Material Master Data (MMD) department has demonstrated significant strategic benefits, particularly in operational efficiency, cost reduction, and data management. This research has positioned RPA as not just a technical upgrade but a core enabler of Wärtsilä's strategic transformation. Through models such as the Critical Factor Index (CFI), Balanced Critical Factor Index (BCFI), and New Scaled Critical Factor Index (NSCFI), the study underscores the alignment between departmental goals and group-level strategies, highlighting both challenges and opportunities inherent in large conglomerates.

RPA's implementation, exemplified through the case study of UiPath, showcases how automation has streamlined processes, improved data integrity, and enhanced the overall efficiency of the MMD department. By automating tasks that were previously manual and prone to errors, RPA has significantly reduced operational costs while enhancing the quality of output. The batch processing capability introduced by UiPath has shortened processing times, thus boosting productivity and responsiveness to business demands. This aligns closely with Wärtsilä's broader digital transformation goals and commitment to sustainable innovation.

Furthermore, this paper addresses two key research questions.

1. **What is the prevailing strategy of the Material Master Data department？**

First, the analysis evaluates the research entity's current strategy and long-term vision. The findings indicate that the target intends to maintain its analyst-focused approach while incorporating core technologies such as Robotic Process Automation (RPA). This strategic combination is expected to support and enhance competitive sustainability. Historically, the strategies of the Martial Master Data (MMD) department have been sustainable, and they are expected to improve further in the future, particularly with the adoption of innovative technologies like RPA. In terms of technology and knowledge management, basic and core technologies carry the least risk, while cutting-edge technologies present the highest levels of risk and uncertainty. Therefore, the department plans to continue its analyst-driven strategy alongside the integration of core technologies like RPA, which is expected to strengthen, rather than compromise, its competitive sustainability and align with its long-term goals.

2. **By implementing Robotic Process Automation in MMD, does the automated system meet the department's strategy expectations regarding cost, quality, delivery, and flexibility?**

The implementation of Robotic Process Automation (RPA) in the MMD department has effectively met expectations in terms of cost, quality, delivery, and flexibility. By using UiPath, the department has cut costs significantly, saving around €6700 annually by reducing server usage and eliminating the need for expensive software. The RPA system has improved data quality and SAP modifications by ensuring accurate data selection and reducing network instability. Time efficiency has also seen a boost, with tasks that previously took 7.5 minutes now completed in just 2 minutes, thanks to batch modification T-codes in SAP. Additionally, UiPath's flexible platform allows for easy customization and scalability, adapting to changing business needs and supporting the department's strategic goals. Overall, the integration of RPA has enhanced operational efficiency, data quality, and system stability, aligning perfectly with the MMD's future operational strategy and preparing the department to meet future challenges effectively.

However, it cannot be conclusively stated that departments with a defensive strategy are unsuitable for adopting RPA automation processes. As a lightweight automation tool, RPA alone may not achieve business process mapping or substantial improvements to existing processes. For departments employing a defensive strategy, using RPA to enhance automation in inefficient processes is not the primary goal. From this perspective, it can be inferred that RPA is not the top choice for these departments. Conversely, for departments with an aggressive strategy, the future convergence of RPA and AI may offer greater potential. Such departments face more diverse and uncertain daily processes without standard procedures to follow, making the construction and integration of AI and machine learning with RPA a more logical solution.

6.1 Limitations of research

The research presented here is based on a single-case study, which inherently limits the generalizability of the results. The study aims to provide practical insights into the implementation of RPA within a specific department of a particular company over a set time frame. The conclusions and findings are therefore subject to context-specific and not necessarily applicable.
In addition, due to limitations in data collection and dissemination, the strategic analysis of MSI provided to organizations in this case study is indicative rather than definitional, as it is based on certain assumptions.
Despite these limitations, the single-case study offers valuable insights. However, a quantitative approach to research might yield results that are more widely applicable.

6.2 Further ideas for research

Quantitative methods could offer a broader understanding of how departments with varying strategies utilize software robotics in their automation processes. Ideally, this would involve surveying departments where RPA has been implemented across different automated workflows.
Additionally, the realm of software robotics encompasses cognitive intelligence and related automation. A comprehensive case study examining the applications of cognitive intelligence within organizations could shed light on this relatively unexplored area, providing deeper insights into its potential applications and benefits.

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APPENDICES

Appendix 1. MSI Questionnaire

CASE STUDIES FOR RESEARCH ON MANUFACTURING STRATEGY

(MSI questionnaire)

Respondent's Name:

Organization:

Country:

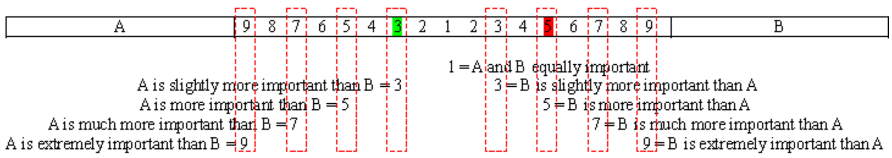
Position in the company:

Contact email:

All information provided by interview is kept confidential and will not be published anywhere.

INTRODUCTION OF USING ANALYTIC HIERARCHY PROCESS (AHP)

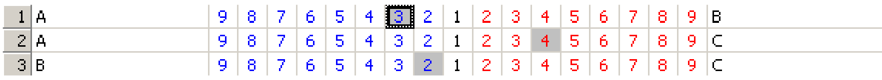
AHP method uses pairwise comparison among all the factors to support decision-making process. All questions in this questionnaire are designed to follow AHP logic. It takes two steps to answer each question. For instance, you are given two different criteria that affect manufacturing decision making. Firstly, you need to compare these two given factors and select one factor which you considered as more important than the other (for example: A is more important than B or vice versa). Secondly, you need to give a weight within scale of 1-9 to indicate in what extent you consider this selected factor is more important than the other one. If the factors are equally important, then select number 1. You can also use even numbers from the scale, if your answer is better suited between odd numbers.



In order to ensure the validity of answers, two incorrect examples with high inconsistence ratio (ICR) are illustrated below. By understanding the causes of ICR, informants are recommended to recheck the consistency after filling the answers.

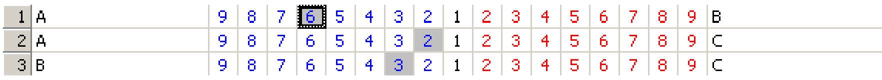
Example 1:

This means A>B & B>C & C>A which is logically inconsistence, so it causes high ICR.



Example 2:

This means A is much bigger than B, and A is a little bigger than C, from these two conditions it can be concluded that C should be bigger than B, but last condition put B is bigger than C, which is contradictory and causes high ICR.



FILLING THE QUESTIONNAIRE

Please evaluate the following criteria in every pairwise comparisons what are more important in your opinion. Please circle (O) the evaluation values for past and future situation considering 2-3 years in the past and future.

Main criteria	**Pairwise comparisons**	**Main criteria**
Costs	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Quality
Costs	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Delivery
Costs	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Flexibility
Quality	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Delivery
Quality	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Flexibility
Delivery	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Flexibility

Table1: Pairwise comparison of four main criteria considering 2-3 years experience in the past.

Main criteria	**Pairwise comparisons**	**Main criteria**
Costs	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Quality
Costs	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Delivery
Costs	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Flexibility
Quality	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Delivery
Quality	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Flexibility
Delivery	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Flexibility

Table2: Pairwise comparison of four main criteria considering 2-3 years in the future.

For validity and reliability checking, please specify roughly the main operations strategy in your company by evaluating the priority weights of Quality, Cost, Time/Delivery and Flexibility.

	Quality %	Cost %	Time/Delivery %	Flexibility %
Past 2~3 years				
Future 2~3 years				

Note: Percentage of Quality, Cost, Delivery and Flexibility altogether is 100%, which means the sum of every row in below table should be 100%.

Appendix 2. Attributes of the S&R questionnaire with weightings

	KNOWLEDGE & TECHNOLOGY MANAGEMENT	
1	Training and development of the company's personnel	Flexibility
2	Innovativeness and performance of research and development	Cost
3	Communication between different departments and hierarchy levels	Time
4	Adaptation to knowledge and technology	Flexibility
5	Knowledge and technology diffusion	Cost
6	Design and planning of the processes and products	Time
	PROCESSES & WORK FLOWS	
7	Short and prompt lead-times in order-fulfilment process	Flexibility
8	Reduction of unprofitable time in processes	Cost
9	On-time deliveries to customer	Quality
10	Control and optimization of all types of inventories	Quality
11	Adaptiveness of changes in demands and in order backlog	Flexibility
	ORGANIZATIONAL SYSTEMS	
12	Leadership and management systems of the company	Cost
13	Quality control of products, processes and operations	Quality
14	Well defined responsibilities and tasks for each operation	Flexibility
15	Utilizing different types of organizing systems (projects, teams, processes...)	Flexibility
16	Code of conduct and security of data and information	Cost
	INFORMATION SYSTEMS	
17	Information systems support the business processes	Time
18	Visibility of information in information systems	Time
19	Availability of information in information systems	Time
20	Quality & reliability of information in information systems	Quality
21	Usability and functionality of information systems	Quality