How to Introduce, Operate and Improve Large Scale Agility in the Robotics and Mechatronics Industry

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***Abstract* — The robotics and mechatronics industry, known for its complexity and rapid innovation cycles, is increasingly moving towards agility to remain competitive and responsive to market demands. However, introducing and managing agility at scale presents unique challenges, especially in large organizations with intricate operational structures. This article provides insights on how to implement, operate, and continuously improve large-scale agility in the robotics and mechatronics sector. Additionally, the article outlines key operational management practices like SAFe and ITIL4 that enable organizations to sustain agility, foster innovation, and enhance their responsiveness to evolving technological and market conditions.**

Keywords— Robotics and mechatronics industry, agility, innovation, SAFe, ITIL, operational efficiency, customer satisfaction, large scale organizations

I. INTRODUCTION

The robotics and mechatronics industry, known for its complexity, advanced technologies, and rapid innovation, is increasingly turning to agility as a core strategy to stay competitive and respond to dynamic market demands. However, achieving agility on a large scale presents significant challenges for big organizations, particularly due to their intricate operational structures, cross-functional teams, and often inflexible legacy systems. This article provides a detailed roadmap for businesses in the robotics and mechatronics sector, offering practical advice on how to introduce, manage, and continually enhance large-scale agility.

It also focuses on the intelligent integration of agile frameworks like Scrum [3], Kanban, SAFe (Scaled Agile Framework) [11], and ITIL4 [1] in large industrial environments, where hardware-software coordination and complex supply chains complicate traditional agile transformations. Key topics include optimizing cross-functional collaboration to eliminate silos between engineering, manufacturing, and product development teams. By cultivating a culture of continuous improvement and adaptability, organizations can overcome traditional barriers to flexibility. The article further discusses how updated operational management approaches can support agility on a large scale while maintaining the high-quality standards and safety requirements essential to robotics and mechatronics.

Moreover, some digital transformation underpinning technologies—such as AI, machine learning, and IoT—is examined in relation to how they enable real-time decision-making and improve organizational responsiveness. Special focus is placed on strategies for managing change, leadership, and navigating the human factors involved in transitioning to agile practices in well-established organizations.

This article ultimately provides actionable insights for leaders and decision-makers seeking to implement or optimize large-scale agility. Whether companies are in the early stages of adopting agile methodologies or looking to scale their current processes, this article offers practical strategies to achieve sustainable agility, continuous innovation, and greater responsiveness to market and technological shifts in the robotics and mechatronics sectors.

This paper will cover SAFe 6.0 as it can scale at different levels: Essential, Program, Large Solution and Portfolio. It will also show the different approach ITIL4 has taken to agility with its Service Value System. Then in the end this article will present measures to support the way forward for the organizations in their path towards scaling agility.

II. WHY THE ROBOTICS AND MECHATRONICS INDUSTRY NEEDS DIGITAL TRANSFORMATION

The robotics and mechatronics industry, at the forefront of innovation, is increasingly recognizing the need to embrace digital transformation to remain competitive and responsive in an ever-evolving market. As the demand for smarter, faster, and more adaptable solutions grows, companies in this sector must integrate digital technologies to streamline operations, enhance product development, and stay ahead of the curve [8].

Increasing Complexity**:** Robotics and mechatronics systems are becoming more complex, involving the seamless integration of hardware, software, and data. Digital transformation allows organizations to manage this complexity more efficiently by leveraging advanced tools such as AI, IoT, and cloud computing.

Faster Innovation Cycles: In today's fast-paced technological landscape, companies must innovate rapidly to keep up with customer demands and market trends. Digital transformation accelerates the development process by introducing automated design tools, digital twins, and simulation models that allow for quicker prototyping and testing. This enables companies to bring new products to market faster while maintaining high-quality standards.

Supply Chain Optimization: Robotics and mechatronics rely on complex supply chains involving multiple stakeholders. Digital transformation can optimize supply chain operations through enhanced visibility, improved demand forecasting, and real-time tracking. Technologies

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like blockchain can increase transparency and trust, reducing inefficiencies and delays in the supply chain.

Customization and Flexibility: As customers increasingly seek customized solutions, digital tools enable greater flexibility in manufacturing and product development. Advanced automation systems, driven by digital platforms, allow companies to quickly adjust production lines to meet specific customer needs without significant delays or costs.

III. Current Challenges Addressed by Digital Transformation

Digital transformation can address key challenges in the robotics and mechatronics industry, such as managing large data volumes and modernizing legacy systems [8]. AI and machine learning provide valuable insights, while digital platforms enhance cross-team collaboration, particularly between engineering and production. Additionally, digital tools improve efficiency of operational activities enabling organizations to scale and adapt quickly to the dynamic market conditions.

Data Management and Analytics: Robotics and mechatronics generate vast amounts of data, but harnessing this data to improve operations is a noticeable challenge. Digital transformation allows organizations to implement analytics and machine learning algorithms to deliver actionable insights from their data. This helps in optimizing performance, predicting potential failures, and making informed decisions based on real-time information.

Collaboration Across Teams: Large organizations in the robotics and mechatronics sector often face challenges in fostering collaboration across departments, particularly between engineering, software, and production teams. Digital platforms can break down silos and facilitate better communication and coordination, improving overall efficiency and project outcomes.

Operational Efficiency: Maintaining operational efficiency while scaling production or expanding to new markets is a key challenge. Digital transformation enhances process automation, workflow optimization, and resource allocation, helping companies achieve higher efficiency levels while reducing costs.

In short, the digital transformation is not just an option but a necessity for the robotics and mechatronics industry. By embracing it, organizations can overcome many of the challenges they face today, from managing complexity and fostering collaboration to enhancing innovation and operational efficiency. In doing so, they will position themselves to lead in an increasingly digital and competitive world.

IV. How Agility Facilitates Digital Transformation

Agility plays a vital role in helping large organizations successfully navigate their digital transformation, particularly when integrated with frameworks like SAFe (Scaled Agile Framework) and ITIL4. These frameworks allow companies to quickly adapt to technological advancements and shifting market demands, enabling them to embrace new digital tools and innovations without being hindered by rigid processes or slow decision-making. Agile methodologies, supported by SAFe and ITIL4, promote cross-functional collaboration, breaking down barriers between departments such as IT, engineering, and production. This enhances the integration of digital solutions and improves overall efficiency.

Furthermore, agility supports an iterative approach to digital transformation, helping the organizations to implement changes in phases. SAFe provides structured guidance for scaling agile practices across the enterprise, while ITIL4 emphasizes the importance of service management in delivering value. This phased implementation enables companies to test new technologies on a smaller scale, gather feedback, and make adjustments before full-scale deployment, thereby reducing risks and ensuring a smoother transition. Additionally, agility prioritizes a customer-centric approach, encouraging organizations to tailor their digital transformation efforts to meet the evolving needs of their clients or users, which is essential in today's fast-changing digital landscape.

V. Scaled Agile Framework (SAFe)

The SAFe framework, as detailed in various sources [5], [7], [9], [10] and illustrated in Fig. 1, includes SAFe [11] core values, principles, roles, and artifacts, structured across four levels of scalability within an organization:

Essential Level: This is the foundational layer for small organizations, including the minimum roles, events, and artifacts, primarily focused on teams and their activities. It closely resembles Scrum [12] at this stage.

Large Solution Level: At this level, additional roles, events, and artifacts are introduced, enabling work to be managed and delivered in Program Increments (PIs) via Agile Release Trains (ARTs).

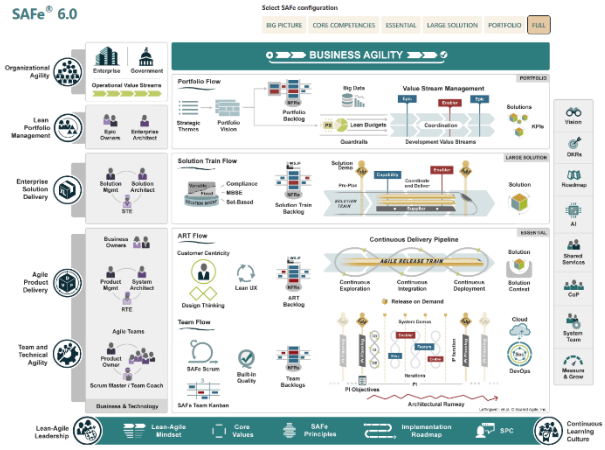

Fig. 1 Full SAFe 6.0 Configuration [11]

Portfolio Level: The portfolio level ensures alignment between enterprise strategy and project execution. It includes roles, events, and practices that govern the Development Value Streams. Small and medium-sized enterprises (SMEs) can use this level to manage their technical solutions, while larger enterprises can utilize multiple portfolios to scale their operations.

Full SAFe: The complete version of SAFe, encompassing all roles, artifacts, competencies, and practices across the different levels, offering full scalability as depicted in Fig. 1

VI. ITIL4

ITIL4 [1] is a modernized framework for IT service management (ITSM) [2] that provides comprehensive guidance on how to design, deliver, and manage IT services effectively. ITIL4 focuses on aligning IT services with the needs of businesses in a rapidly evolving digital landscape. It builds on earlier versions by incorporating Agile, DevOps, and Lean practices, promoting flexibility, collaboration, and

continuous improvement. The framework emphasizes value creation through service management and helps organizations manage risk, optimize resources, and deliver high-quality services that drive business success.

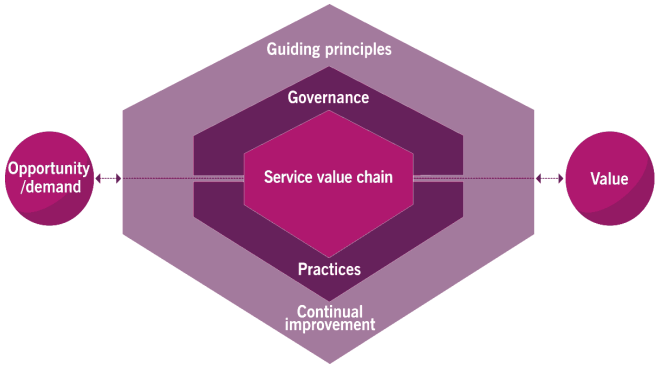

Figure 2 Service Value Chain [1]

The Service Value Chain (SVC) Fig. 2 in ITIL4 plays a crucial role in facilitating digital transformation by outlining the essential activities needed to create and deliver value to customers and stakeholders in a rapidly evolving environment. This flexible operating model allows organizations to adapt their processes to meet specific digital needs. The value chain encompasses six interconnected activities: planning ensures alignment with the organization's vision and goals, while improvement focuses on the ongoing enhancement of services, processes, and practices to drive efficiency and effectiveness in a digital context. Engaging with stakeholders fosters strong relationships and provides insights into their needs and expectations, which is vital for successful digital initiatives. The design and transition phase involves developing and implementing innovative services that leverage digital technologies to fulfill stakeholder requirements. Additionally, acquiring or building the necessary components for service delivery is integral to this transformation. Finally, delivering and supporting services is essential for meeting established service levels, particularly in a digital landscape. By utilizing the Service Value Chain, organizations can adopt a best practice approach to service management that not only enhances their ability to create and deliver value but also empowers them to respond swiftly and effectively to the challenges of digital transformation.

VII. Measures for Improving Agility Implementation in Large Organizations

Based on current agile methodologies such as SAFe and ITIL4 described shortly in the previous chapters here will be presented several specific measures that can enhance agility at all levels within large organizations. These measures can be divided into two main groups: the creation of a new methodology and the use of technical tools to actively support this methodology.

The creation of a new methodology includes the following six measures:

1) Introducing a permanent quality control system with clearly defined and measurable goals (Key Performance Indicators (KPIs)), as well as roles and responsibilities at all levels

2) Establishing a new quality control practice that resembles the "Service Level Management" practice from ITIL4 but is expanded to encompass the entire organization, including teams using SAFe.

3) Creating a new role at the strategic and tactical levels that follows best practices related to quality control across all "trains" and value streams.

4) Developing a new practice similar to the "Continual Improvement" practice from ITIL4, but upgraded to cover the entire organization, including teams using SAFe.

5) Establishing a new role at the strategic and tactical levels that follows best practices related to continual improvement across all "trains" and value streams.

6) Creating a new Agile Release Train (ART) focused entirely on the continuous improvement of product and service delivery.

The proposed measures aim to enhance agility within large organizations in the robotics and mechatronics industry by leveraging frameworks like SAFe and ITIL4. Introducing a quality control system with pre-defined KPIs fosters accountability and transparency, enabling teams to monitor progress and make data-driven decisions.

Establishing a quality control practice that mirrors ITIL4's "Service Level Management" across the organization ensures consistent quality standards, enhancing customer satisfaction. Creating strategic and tactical roles focused on quality control and continual improvement empowers leaders to champion agile practices and maintain alignment across all "trains" and value streams.

Developing a tailored continual improvement practice promotes a culture of ongoing enhancement, allowing organizations to adapt to market changes effectively. Finally, establishing a dedicated Agile Release Train (ART) for continuous improvement streamlines efforts in enhancing product and service delivery, facilitating faster innovation cycles.

Together, these measures create an agile environment, enabling organizations to respond swiftly to changes, improve operational work, and support the innovation efforts in a rapidly evolving digital landscape.

The technical tools that can be employed should be based on the latest AI/ML algorithms [3], [4], [6], such as in Reference [13] which presents an ITIL and AI based Model to achieve high-quality electronic services. Additionally, a survey can be utilized to gather data and possible improvement points. The survey will be focused on agility within large organizations, and will include specially developed questions which are designed to assess various aspects of agility, such as team collaboration, responsiveness to change, and the effectiveness of current agile practices. Not to forget also the load on the people working in this environment. This load can be sometimes the difference between the success and the failure. The goal is to collect and process data because of the large scale and complexity of the research subject, facilitating the necessary agility at all levels.

This gathered data will be both quantitative and qualitative. Quantitative data will provide details to whether the planned delivery times align with the actual ones, while qualitative data will include an analysis of survey responses regarding proposed improvements and their impact on subsequent delivery cycles.

Furthermore, advanced machine learning algorithms, such as gradient boosting, can be applied to the data gathered from the survey. These algorithms will enhance the assessment of the status of the agility within the organization, enabling more accurate evaluations of

operational performance. By analyzing the survey data, gradient boosting can also assist in forecasting future trends and potential challenges, providing organizations with actionable insights that inform decision-making and strategy development. This integration of AI/ML with survey data will ultimately support the organization's efforts to achieve sustained agility and adaptability in a rapidly changing environment.

VIII. Conclusion

In today's dynamic market, the robotics and mechatronics industry face increasing customer demands for quality and innovative features. As organizations strive to meet these expectations, many have turned to Agile methodologies as their framework of choice. While some companies have adopted Agile as their foundational organizational model, others find it necessary to seek guidance on implementing it, especially at scale.

To facilitate effective scaling, the Scaled Agile Framework (SAFe) is introduced as a viable solution. SAFe integrates three critical bodies of knowledge: Lean, Agile, and DevOps. Combining these frameworks can be complex, particularly for organizations starting from scratch and aiming to scale effectively. To support this process, SAFe outlines four levels of implementation: Essential (Team), Large Solutions, Portfolio, and Full. These levels encompass roles, events, artifacts, and numerous best practices essential for Agile success. Central to SAFe are the Agile Release Trains (ARTs) and Solution Trains (STs), which leverage a Program Increment approach similar to Scrum, making it accessible for implementation.

On top of what is presented in SAFe, the ITIL4 framework plays a crucial role in enhancing organizational agility within the robotics and mechatronics industry. ITIL4 focuses on service management and provides a comprehensive guide for organizations to create value through services. It emphasizes the Service Value System (SVS), which integrates various components—such as governance, management practices, and continual improvement—into a cohesive approach to delivering value to customers.

By incorporating ITIL4 practices, organizations can ensure that their service delivery aligns with customer needs while optimizing resources and processes. This alignment is essential in a fast-paced industry where technological advancements and customer expectations are constantly evolving.

To enhance agility in large robotics and mechatronics organizations, six key measures are proposed. First, implementing a permanent quality control system with defined Key Performance Indicators (KPIs) will drive accountability and maintain standards. Second, adopting a quality control practice based on ITIL4's "Service Level Management" will effectively monitor service delivery across all teams using SAFe. Third, creating strategic roles focused on quality control will ensure adherence to standards across Agile Release Trains (ARTs) and value streams. Fourth, developing a practice similar to ITIL4's "Continual Improvement" will promote ongoing enhancements. Fifth, establishing additional roles for continual improvement will foster innovation and responsiveness. Lastly, forming an ART dedicated to continuous improvement in product and service delivery will cultivate agility.

Furthermore, the integration of machine learning (ML) algorithms can enhance the introduction and operation of agility at all levels within the robotics and mechatronics industry. By analyzing data collected through Agile and ITIL4 processes together with data gathered from a dedicated agile survey, organizations can gain valuable insights, optimize performance, and better respond to evolving market demands.

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