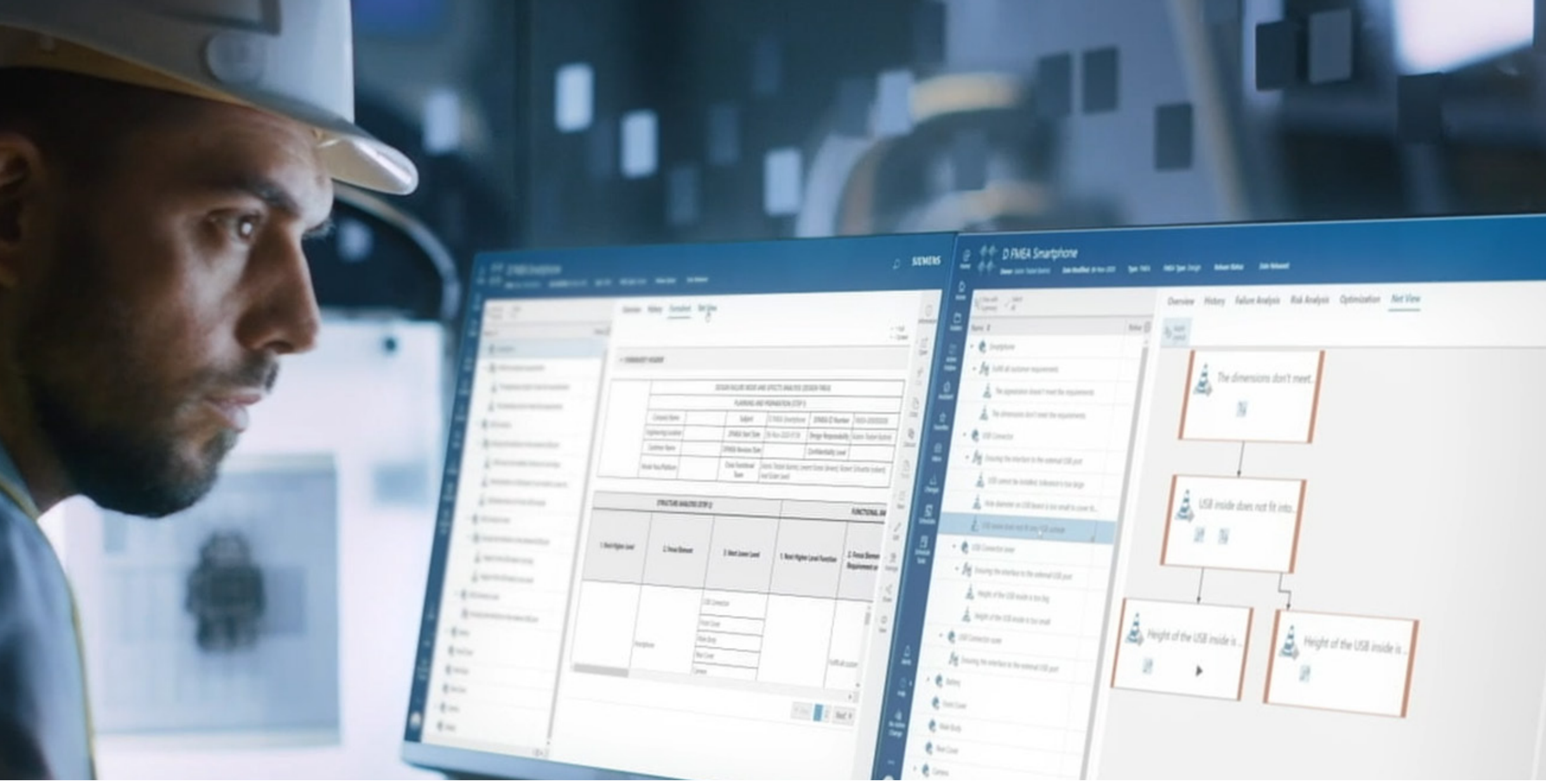

DIGITAL INDUSTRIES SOFTWARE

Leveraging failure mode and effects analysis

Using quality capabilities of Siemens QMS to effectively assess design and process risks

Executive summary

In the automotive industry, design and manufacturing defects can have serious ramifications: increased warranty costs, impaired product functionality and safety, an inability to meet required industry standards and more. The ability to assess risks associated with possible product and process failure is essential. Failure mode and effects analysis (FMEA) is a critical preventive tool for effectively assessing risk. Making sure quality is fully considered and addressed before the finished product rolls off the production line helps developers and manufacturers avoid changes in later production stages. This saves money and helps produce high-quality results. Providing a powerful FMEA, closed-loop quality solution enables automotive developers and manufacturers to perform a complete risk analysis and reduce risks and costs. With the help of the Quality Management System (QMS) from Siemens Digital Industries Software, which is integrated on a collaboration platform, we support doing things right at beginning to avoid complications.

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Introduction

The fast-changing automotive market presents challenges and opportunities
The automotive industry is facing accelerated change and growing challenges related to product and process quality development. How can automotive manufacturers deliver quality, accountability and compatibility of automotive products in this environment?

Although these challenges are daunting, each one is accompanied by a new opportunity for competitive advancement. Market trends spanning these challenges and opportunities include more unpredictable global markets and individualized mass production. Besides these, there is a constant reduction of profit per vehicle due to fierce competition, particularly from emerging markets and outsourcing to top tier suppliers.

Digitalization and disruptive technologies have also impacted automotive manufactures. Therefore, they need to optimize digitalization to deliver more innovative products and handle complex manufacturing needs.

These innovations open new opportunities to increase levels of performance and quality. Additionally, car manufacturers and their suppliers must deliver zero-defect components and systems, manage quality according to automotive standards such as, International Automotive Task Force (IATF) 16949.

As a result of these external challenges, original equipment manufacturers (OEMs) and first tier supplier (FTS) feel pressure to reduce cost, rapidly deliver and improve quality.

In the National Highway Traffic Safety Administration (NHTSA) "2020 Recall Annual Report"[1], the defect and compliance recall types show a constant increase over the years. The issues affect vehicles, equipment, child seats and tires. The data reinforces the trends from previous years. "In 2019 alone, 38.5 million vehicles were affected by 881 recalls, up from 19.7 million vehicles in 647 recalls in 2010."[2]

What risks are associated with implementing new innovations? What new scenarios must FMEA account for as future technologies become a part of regular operations in an automotive plant?

Figure 1. Fast-changing market presents challenges and opportunities.

Four key manufacturing challenges

The combined effects of these market forces on automotive industry quality can be summed up in four key challenges. Each of these can be addressed successfully by a holistic digital approach to quality.

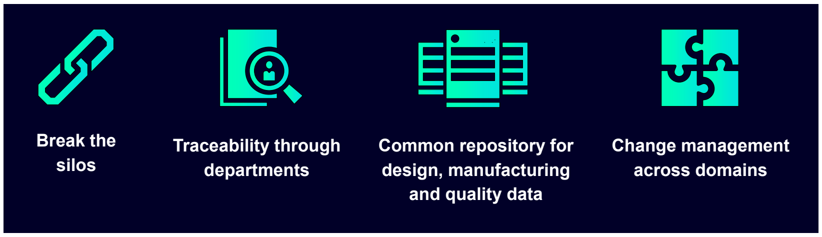


Figure 2. Key challenges.

1. Break the silos between engineering, manufacturing and quality departments.
2. Allow traceability of all activities across the entire organization.
3. Provide a common repository of relevant data coming from all company domains.
4. Deliver a common change management process.

Moving from disjointed to holistic quality management

Compared to other complex manufacturing companies, the automotive industry has historically led the way in automation and digitalization. A significant portion of automotive companies have implemented digital solutions, which include quality management. However, many systems are homegrown or not a part of a standard platform or holistic approach.

A fragmented quality landscape with disparate, outdated and disconnected systems affects all efforts to succeed. To improve the situation, manufacturers need to leverage standard quality best practices. They also need to use a digital approach for managing quality to significantly reduce the risk of poor-quality performance.

A closed-loop quality solution for the entire product lifecycle is key for all manufacturers and their suppliers. This allows them to address development and manufacturing challenges and make sure they can meet their business targets.

Siemens builds its systems to support digital transformation across the entire product lifecycle and end-to-end quality. Leveraging several elements of the portfolio, Siemens QMS extends its connections from design to manufacturing on the shop floor.

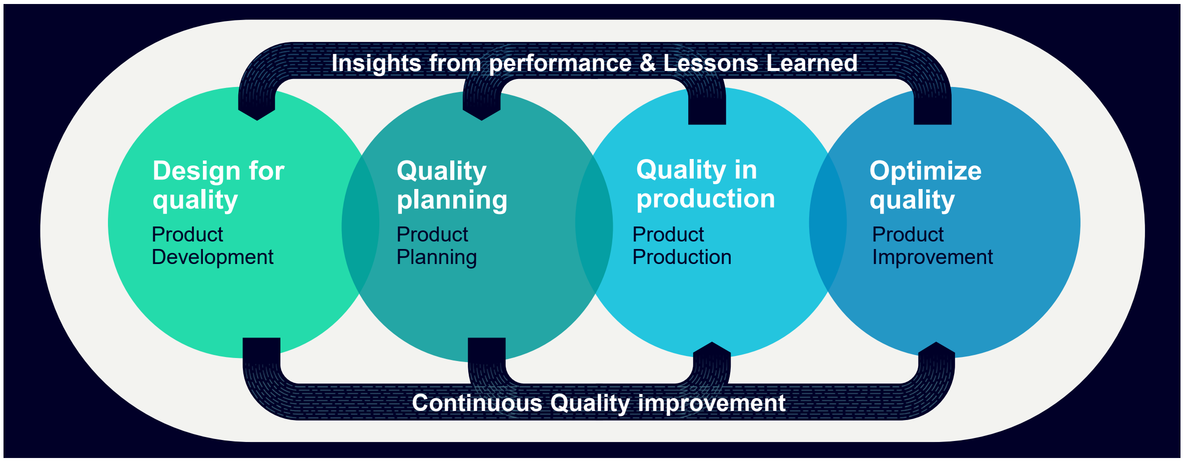


Figure 3. Holistic quality view across domains.

A constant flow of information: from end-to-end

The quality of products and processes is essential to achieving company goals. Quality defines the competitiveness of each manufacturer. Standards for high quality require integrating quality processes with capabilities to implement continuous improvement throughout the product lifecycle, from ideation and realization to product maturity.

Siemens extends the conventional plan-do-check-act (PDCA) cycle in Siemens QMS to engineering and manufacturing domains. This holistic solution performs functions in all stages, enhancing product and process quality and efficiency throughout the development process.

In support of this end-to-end quality, Siemens QMS incorporates powerful quality functions through all four stages of a production lifecycle:

Phase 1: Design for quality - Using modern methods of development, a product begins as a system, then becomes a logical structure before being developed as a virtual product. The quality of a product is already determined in the design phase. Quality requirements are developed during systems engineering and captured in the 3D model, which can be used for an aggregate tolerance analysis.

The quality information, in the form of product manufacturing information (PMI), are relevant in downstream processes. Integrating the quality data early in the design process can provide a more competitive and cost-efficient advantage.

Phase 2: Quality planning – The quality team takes all necessary steps to understand the customer's needs and design a robust product and process. This planning helps the automotive manufacturer avoid changes during later phases of the project, which can raise costs and lower quality. During the planning phase, Siemens QMS is used to manage critical planning tasks, including advanced product quality planning (APQP) and FMEA.

Phase 3: Quality execution – A perfectly planned product requires well-managed production and supply processes to achieve the desired quality.

Phase 4: Quality improvement – Any deviations on the real product are recorded in a non-conformance and resolved through problem solving with effective root cause analysis methods. The common change management feature distributes the changes to all stakeholders in the loop, so the product development process continuously improves.

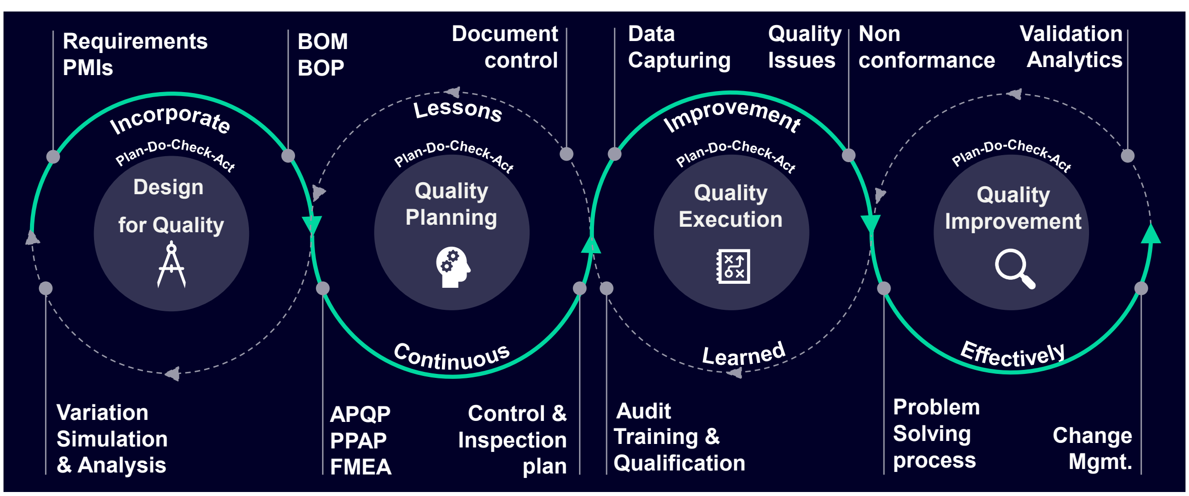


Figure 4. Holistic quality flow across domains.

By managing all processes, manufacturers can be more responsive and compliant. They can avoid replicating or losing information among several departments or plants.

As a result, manufacturers or their suppliers can control processes for more consistent quality.

How a closed-loop QMS supports FMEA preparation and realization

As a fundamental part of the quality planning process, automotive companies need to manage numerous risks in their daily business activities to avoid recalls or adverse events that can bring brand damage. These risks can result from:

1. Introducing new equipment and major changes in production processes
2. Introducing new products, materials and technologies
3. Changing supplier outsourcing for a component alternative for cost reduction

The quality standards and guidelines regulating the automotive industry require risk to be quantified and considered for all key processes and decisions. The International Organization for Standardization (ISO) 9001:2015 does not specify a method but emphasizes the importance of risk management.

IATF 16949:2016 proposes a specific methodology, which uses FMEA as the primary identification tool. As manufacturers apply FMEA to each specific situation, it is important to understand how the standards and guidelines expect risk to be addressed. There is no mandatory requirement to eliminate all risks but an expectation to identify, document and manage risks.

It should also be noted that FMEA is one of the areas auditors investigate to assess how a company manages quality and failure. This means the importance of FMEA and the quality of the planning stage cannot be overstated. Furthermore, they are crucial to minimizing potential defects prior to production to achieve advanced product quality, reduced warranty claims and costs. The Pareto principle states, for many outcomes, roughly 80 percent of the consequences come from 20 percent of the causes.[3] This is an area that Siemens' FMEA solution can handle.

As a methodology that allows companies to assess the risks associated with possible product or process failure, FMEA is applied to two primary areas – design and process. It identifies, quantifies and controls risks during product introduction.

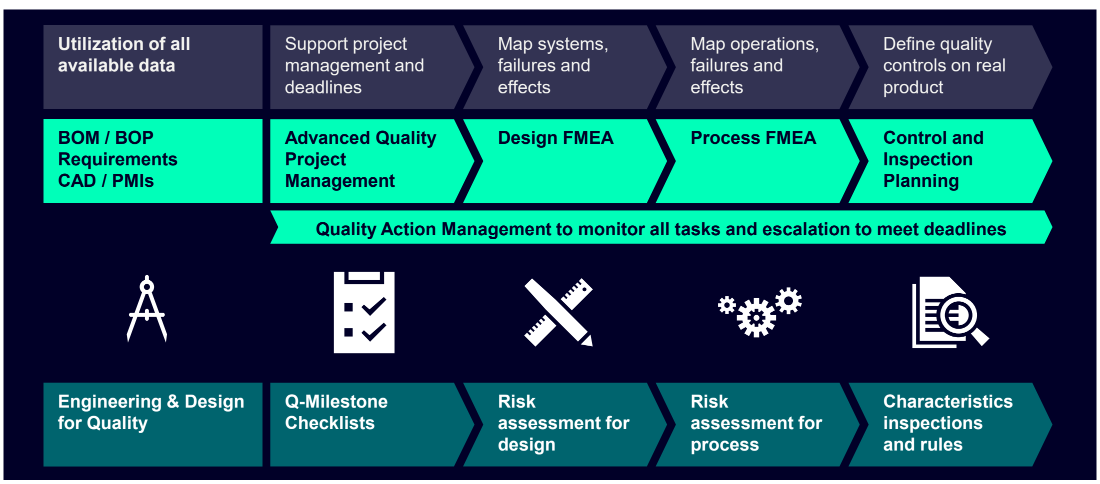


Figure 5. Focus on quality planning stage.

Design failure mode and effects analysis (DFMEA) applies an analytical methodology to discover potential failure when developing a new product and avoid or mitigate them early on.

Process failure mode and effects analysis (PFMEA) discovers risks in new manufacturing processes and helps make them as robust as possible.

In either case, the interdisciplinary quality team begins to assess these risks and weigh them against opportunities by repeating a three-step process:

5. Identify what can go wrong.
6. Analyze the chances of a failure and associated consequences.
7. Act to mitigate the cause and reduce its priorities.

A forward-looking approach to quality initially comprehends the needs of the customer and then builds quality into the design of both product and process. As a product is planned and designed, the quality team must answer these questions:

1. What are all the relevant characteristics of the product or process that must be considered?
2. What are the quality-critical characteristics of the product or process?
3. What are our quality targets and how can we meet them?
4. What are the potential failures and what effects would they have on the finished product or end-user?
5. How do we communicate the main development concerns to top management?
6. How do we define our priorities to address the risks to our stakeholders?
7. Are we involving the right expertise across departments to manage product or process development?

To address these questions, the first task is to define the quality teams – a core team and an extended team that will perform FMEA-based risk assessment. The teams should be cross-functional and led by a facilitator, which is typically called the FMEA moderator. Team members may be subject matter experts (SMEs) covering different functions of the company: quality, manufacturing, research and development (R&D), purchasing, maintenance and service and suppliers of critical components.

A fragmented approach to quality can become problematic as quality teams determine how to manage all FMEA documents during preparation and after maintenance. As a company introduces a new product, a large quantity of information must be communicated: describing systems in long text files, collecting requirements with subassembly and category explanations, collecting characteristics on spreadsheets and more. Every week, team members may be called on to re-read another hardcopy of a file with updates. For example, the reams of files or hardcopies may reflect excellent work of classification, data collection and archiving. However, it is important to understand the amount of time this manual work consumes.

In comparison, the holistic approach of Siemens QMS moves all activities from paper to a common, familiar and easily navigated user experience (UX). Its responsive user interface (UI) enables team members to view critical information on their computers. Siemens' solution replaces manual tracking of a disparate set of quality activities using decentralized tools across the enterprise, with a centralized database housing all quality-relevant data.

Siemens FMEA enables quality personnel to organize complex designs and processes in a tree structure and forms supported by net diagrams. This facilitates sorting data at all levels as well as quick and efficient navigation of complex structures. Quality teams can define system elements, functions and failures. Users can create links to verify failure consequences and causes and induce prevention and detection actions. Clear lists of products, components, parts and connections between functions and failures can be displayed.

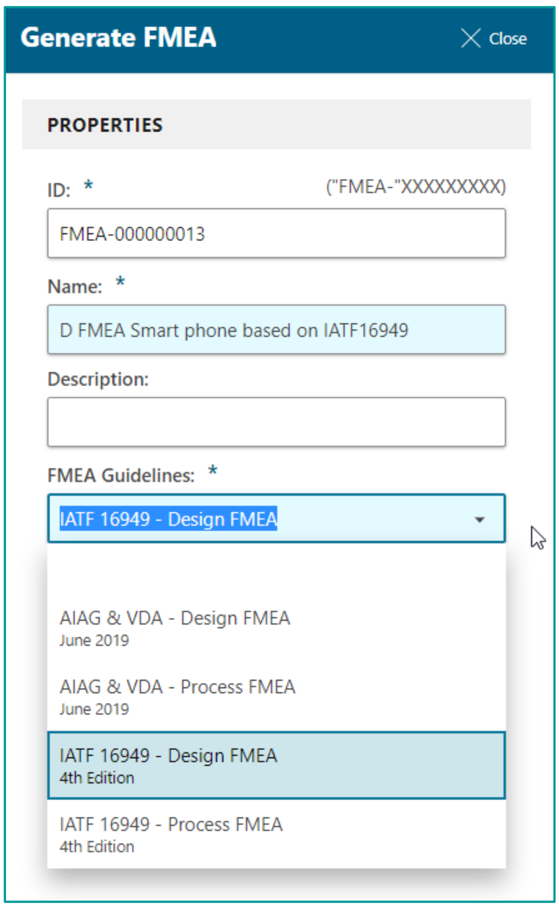


Figure 6. Possibility to generate FMEA by following different guidelines.

FMEA supports all quality processes and most standards

Through an optimal exchange of data and usage of the collaborative Teamcenter® software platform, which is a part of the Xcelerator™ portfolio, the comprehensive and integrated portfolio of software and services from Siemens, FMEA leverages several process integrations with other quality modules and domains.

This process helps to navigate complex structures quickly and efficiently in a tree structure, which is supported by net diagrams for sorting data at all levels. The design of a product is supported by managing all lists of products, components, parts and connections. It also includes a systematic view of the correlation between different components and a picture of the entire manufacturing process.

One of the most important outcomes of this integrated approach to quality is the ability to perform FMEA in accordance with most industry standards.

The supported FMEA guidelines have been extended and the IATF 16949-based form sheet is available. The risk priority number (RPN) can be used in addition to the action priority (AP) by selecting the preferred FMEA guideline. You can customize the form sheets via configuration and style them according to your needs.

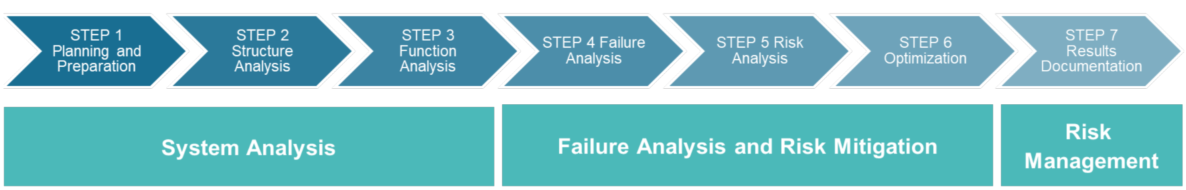
Siemens QMS supports the new harmonized approach initiative proposed by the AIAG & VDA FMEA Handbook, the new automotive industry reference manual for FMEA.

FMEA supports the new seven-step approach for DFMEA and PFMEA definition and realization, including tables for risk assessment hints (severity, occurrence and detection). The system uses the new AP to define the risk. All data is visible in the new form sheet in accordance with the handbook.

It is important to consider how a native quality solution on a collaborative platform supports an automotive manufacturing company in following the new methodology and leveraging several capabilities in a unique environment.

Our quality portfolio supports the seven-step approach prescribed by the harmonized AIAG and VDA FMEA Handbook.

1. Planning and preparation
2. Structure analysis
3. Function analysis
4. Failure analysis
5. Risk analysis
6. Optimization
7. Results documentation



Source: AIAG & VDA FMEA Handbook 1st Edition.

Figure 7. Main FMEA steps according AIAG&VDA Handbook 2019.

To prepare and plan the FMEA, the quality team defines and details what is included and excluded in the FMEA project. They also define the team and all tasks from specific checklists to create their own specified list. All checklist points can be tied to specific quality actions and visualized in a Gantt chart. All information about the project is inserted in the header of the form sheet to provide a clear overview of the FMEA projects.

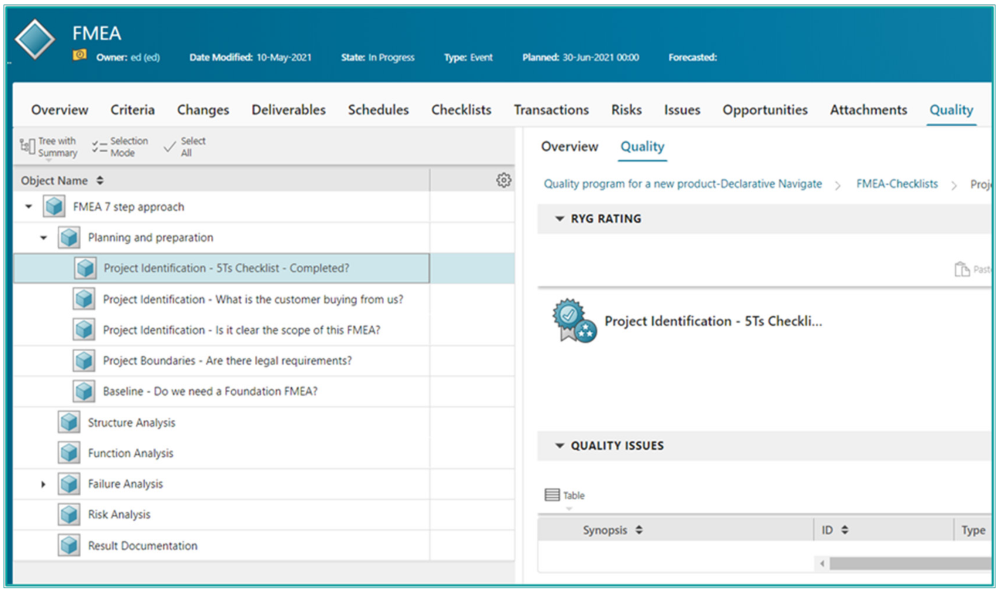


Figure 8. Design DFMEA quality planning (quality checklist and milestone definition).

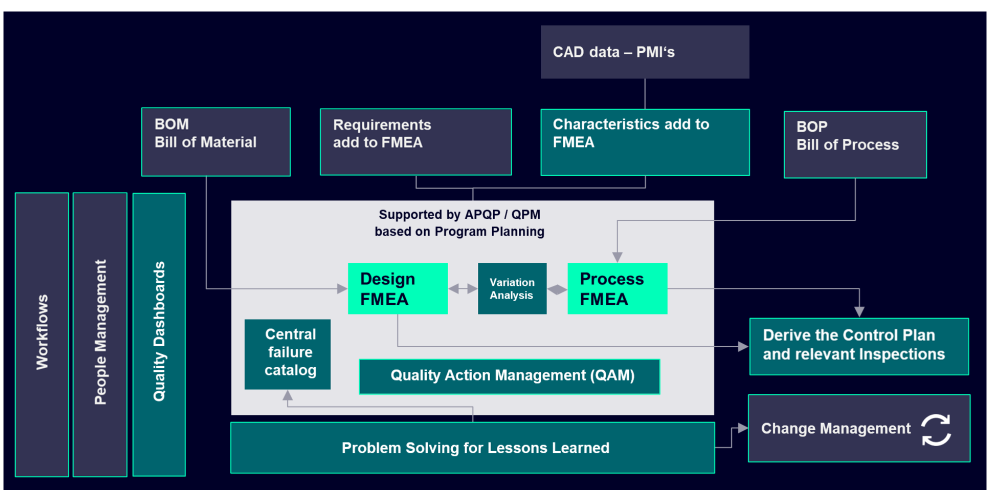


Figure 9. One single repository for all data related to the specific project.

Since FMEA is natively integrated into the collaboration platform, the team can have direct access to all engineering data, like bill-of-materials (BOM), bill-of-process (BOP), drawings and 3D-models (leveraging Teamcenter).This means information generated in one area or department can be accessed and leveraged throughout the entire application. This integration enables an optimal exchange of data points and promotes the use of a company knowledge database.

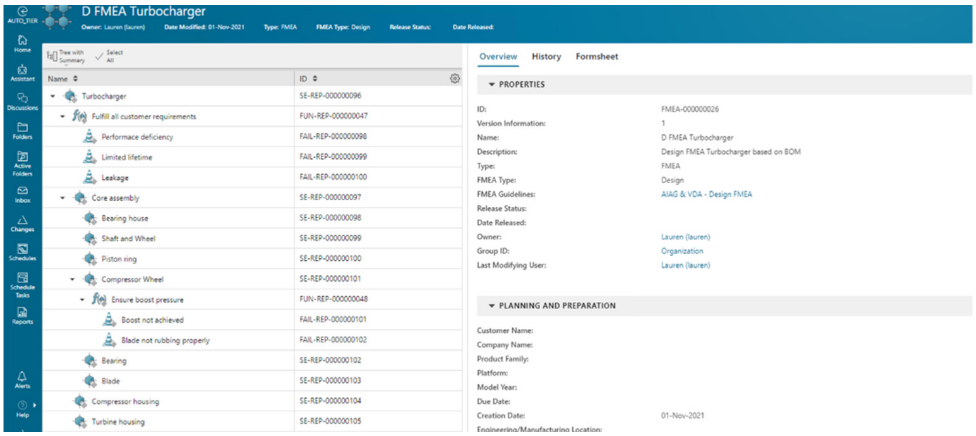


Figure 10. Design DFMEA starting a new FMEA process.

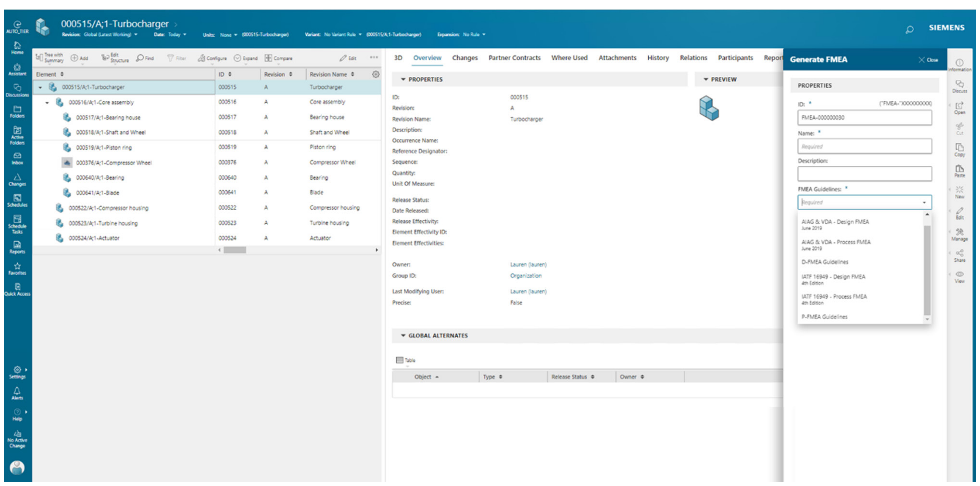


Figure 11. DFMEA reuse of BOM.

Here, the team creates the tree structure.

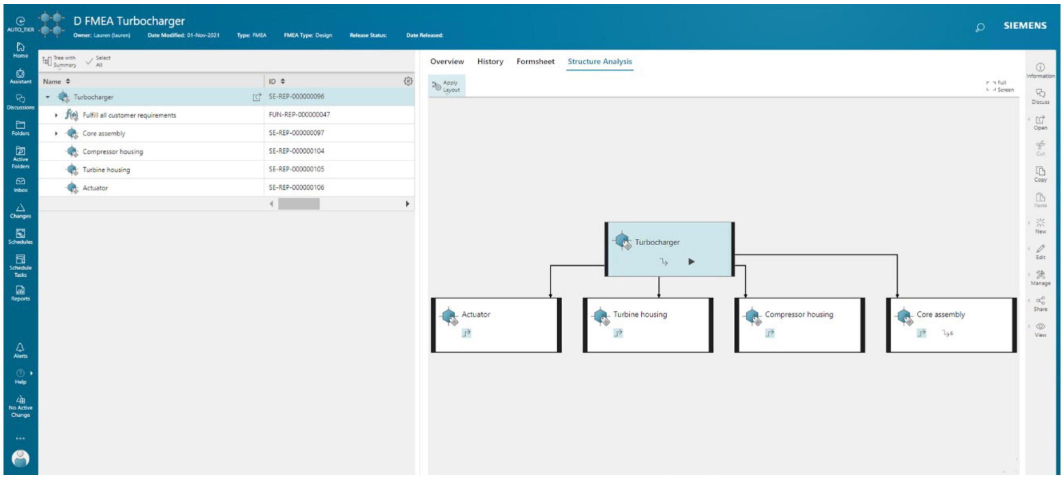


Figure 12. DFMEA system elements' definition.

Using the FMEA module, the tree of functions can be generated to create the proper association of product and process requirements to these functions and related system elements. This means the requirements management can be fully integrated into the FMEA. Furthermore, the function relationships can be defined and visually represented in the function net views.

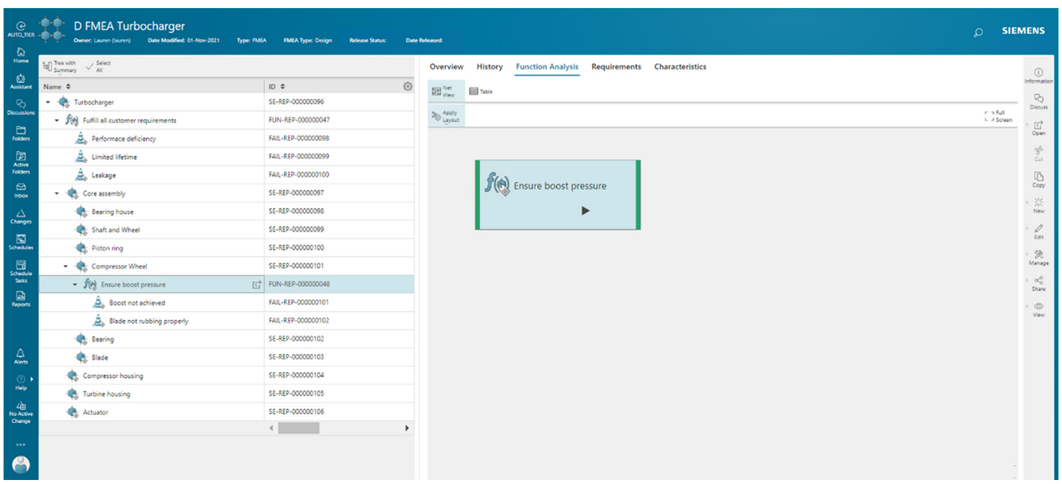


Figure 13. DFMEA functions creation in net.

The FMEA module can be used to support the quality team as they associate failure modes, effects and causes. The team can work with a failure tree and net view.

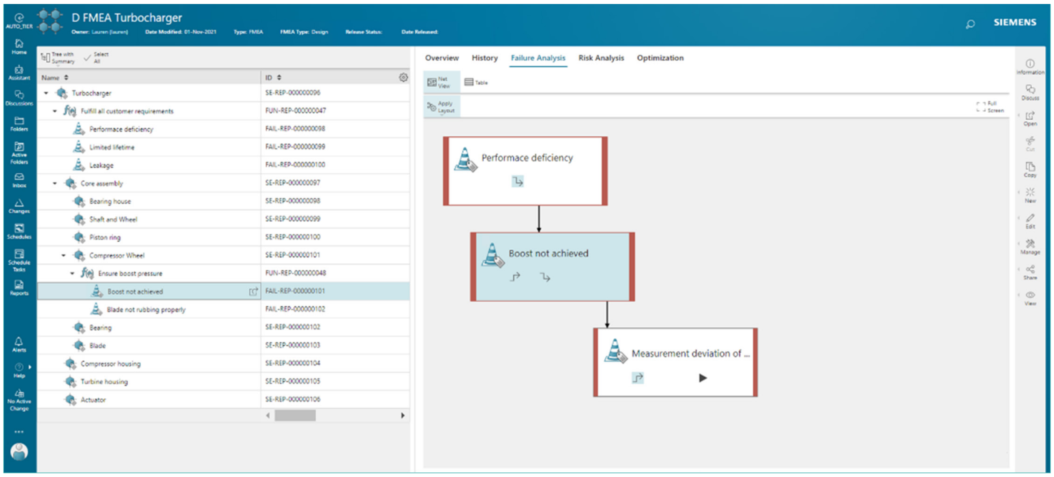


Figure 14. DFMEA failure elements creation in net.

The FMEA module is used to:

1. Assess severity, occurrence and detection
2. Define preventive controls for failure causes
3. Define detection controls for failure causes
4. Identify the AP level

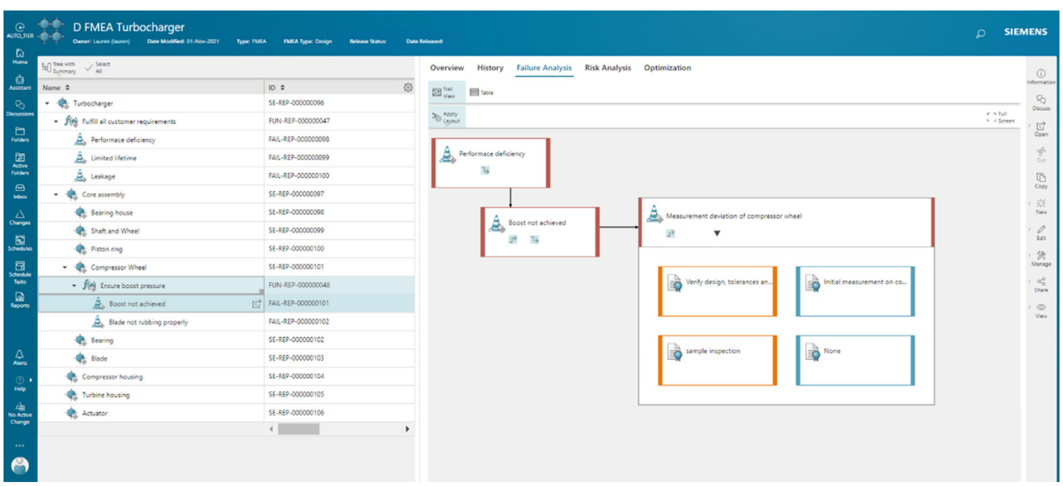


Figure 15. DFMEA Graphical overview.

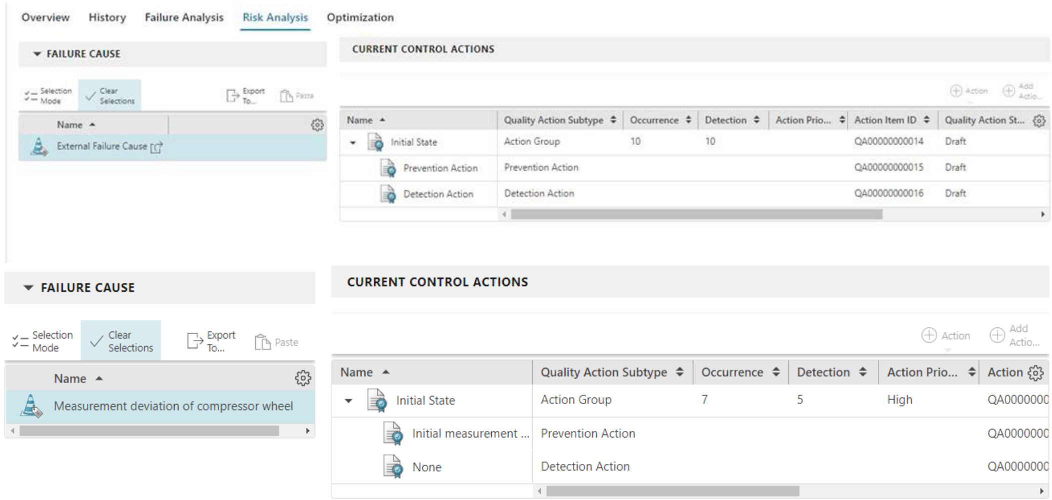


Figure 16. DFMEA risk analysis (occurrence, detection and AP).

The user can optimize AP, define further prevention or detection controls to diminish the risks and evaluate the controls' effectiveness.

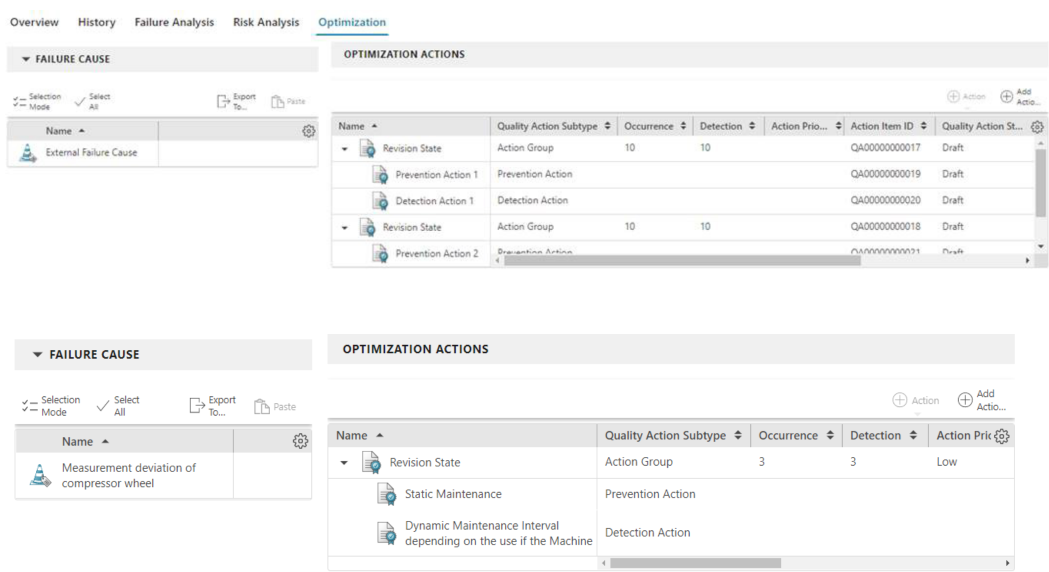


Figure 17. DFMEA optimization (occurrence, detection and AP).

To summarize FMEA outcomes, specific reports can be created, configured and communicated to stakeholders to obtain the right support from top management.

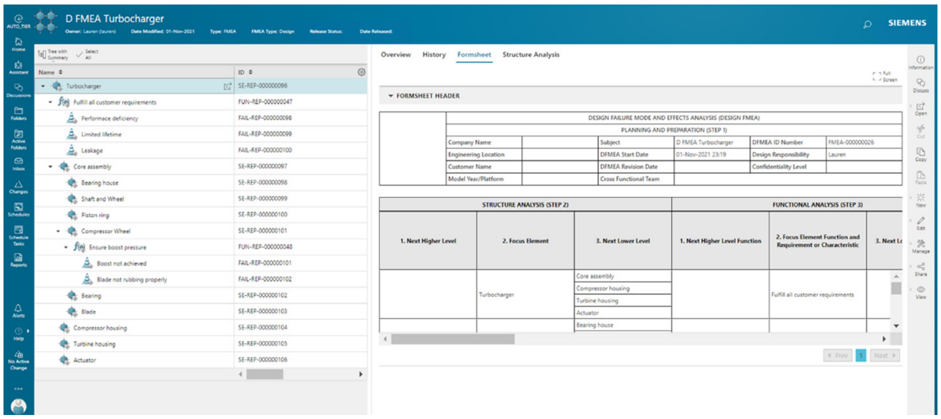


Figure 22. DFMEA visualization of all data in standard form sheet.

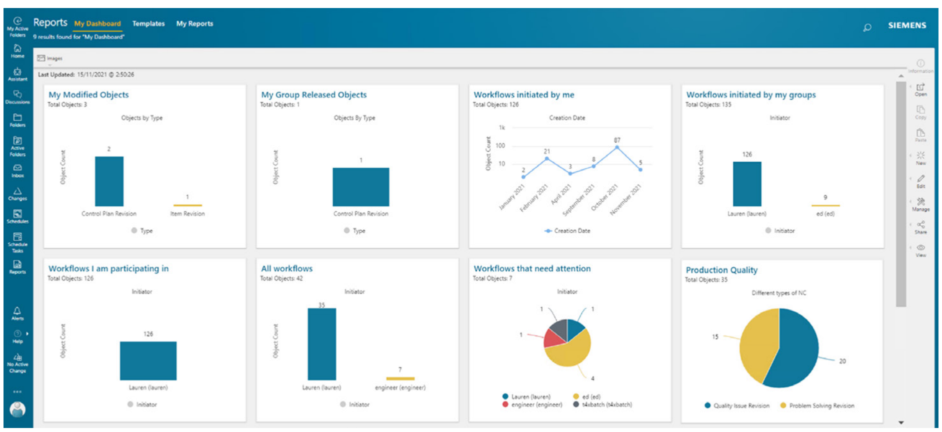


Figure 23. Possibility to create dashboard for reporting data.

Conclusion

Siemens is expanding Xcelerator to include capabilities provided by the cloud, enhancing collaboration with new functionalities being added over time. We call this Xcelerator as a Service. Xcelerator as a Service, a foundational component to the Xcelerator software portfolio, is the multi-cloud platform as a service offering powered by Mendix™, the leading low-code platform. Through a set of app services, such as collaboration, search and IoT services, Xcelerator as a Service enables secure development services built on a common set of standards and principles and can easily be integrated into other applications. Collaborating through the cloud with partners and suppliers enables you to plan, develop and deliver quality products faster.

FMEA capabilities provided by Siemens QMS enable manufacturers to:

1. Access all available engineering data through native integration with Teamcenter
2. Eliminate need for local installations to reduce maintenance
3. Support customer-specific configurations and customizations
4. Improve UX with a modern and innovative UI
5. Support closed-loop quality with product lifecycle management (PLM) integration

Virtually all automotive manufacturing companies face unprecedented challenges – and unprecedented opportunities – from intensifying market conditions. There is a demand to shift quality operations from a highly fragmented, heterogeneous and disconnected landscape to a unified digital ecosystem. Siemens QMS enables automotive companies to meet the demands of today's market and understand this shift with a system that is easy to use and adopt – setting you on your digital journey with confidence.

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