Development of an AI-Supported Optimization and Decision-Support Industrial SaaS Platform for FMEA Risk Management

AI-powered FMEA EXCELLENCE, ST05-224/2025, StarTech Innovation Support Program, Period (2025-2026)

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Abstract

The application of Failure Mode and Effects Analysis (FMEA) in the automotive industry is prescribed by international standards and is implemented across all companies operating within the automotive supply chain. Although originally designed as a valuable engineering tool, it often remains merely an administrative obligation carried out by quality departments, without fulfilling its primary purpose, i.e. improving the reliability of products and processes. Even when companies approach FMEA seriously, they encounter numerous challenges, such as manual data entry, incomplete records, lack of historical risk data, and various other practical difficulties. This paper presents the development of FMEA Excellence, implemented as a cloud-based Software as a Service (SaaS) platform, aimed at transforming FMEA into a reliable decision-support tool. The platform is designed to automate key FMEA activities, including data collection and processing related to products and processes, risk prioritization, and the generation of action recommendations. In addition to improving risk management, the platform aims to reduce the time required to perform FMEA, lower costs, and enhance the effectiveness and efficiency of FMEA-related activities, while also enabling transparent real-time monitoring of team performance. The key functionalities of the platform are based on a combination of artificial intelligence tools, including evolutionary artificial intelligence and Retrieval-Augmented Generation (RAG) integrated with large language models (LLMs), as well as optimization methods.

Keywords: FMEA; AI-powered; FMEA Excellence; automotive industry; decision-support tool; risk management; artificial intelligence; RAG; LLMs; industry, UN SDG 9, UN SDG 12

1. Project Background and Objectives

Quality engineers and quality management teams in modern industrial production, particularly in the automotive industry, are increasingly exposed to pressures related to project delivery deadlines, while simultaneously being

required to comply with stringent international standards, as well as internal and external audit requirements. As a result, valuable engineering tools commonly used in practice, such as Failure Mode and Effects Analysis (FMEA) [1], are often perceived as administrative obligations without clear practical purpose or contribution. Their implementation is further complicated by tight time constraints, incomplete data, and a reactive approach to problem-solving, where issues are addressed only after they have already manifested and become critical.

The latest version of the FMEA Handbook [1] for the automotive industry, which provides guidelines for its implementation, was published in 2019 by the Automotive Industry Action Group (AIAG) and the Verband der Automobilindustrie (VDA). Although certain improvements in conventional FMEA have been observed since the introduction of this handbook, several significant challenges related to its practical application still remain unresolved. Numerous studies have shown that the introduction of additional decision-support tools is necessary in order to fully realize the potential of FMEA in industrial practice [2]. Furthermore, research indicates that the FMEA maturity level of companies in the Republic of Serbia is often limited to the use of Excel-based approaches, representing the most basic level of administrative analysis [3].

Precisely due to the numerous challenges that automotive companies face regarding FMEA, the motivation for the FMEA Excellence project emerged with the support of the StarTech program [4] (see the logos in Figure 1), with the aim of developing an AI-supported approach to FMEA implementation in practice.



Figure 1. Logo of the FMEA Excellence project (left) and the StarTech program logo (right)

The main objective of the project is to develop an intelligent Software as a Service (SaaS) platform aimed at transforming FMEA from a static Excel document into a dynamic decision-support system. Data collection and processing would are automated through the application of artificial intelligence (including evolutionary artificial intelligence and knowledge-based approaches) and optimization methods. The integration of these concepts aims to reduce the time required for FMEA creation and maintenance, lower costs, and prevent failures, while also contributing to improved product quality and operational efficiency. In addition, the SaaS platform would enable compliance with standard requirements and real-time monitoring of changes, ensuring consistency and traceability.

2. Problem Statement and Motivation

Although prescribed by the IATF 16949:2016 standard [5] and defined by the FMEA Handbook [1], the modern application of FMEA in the automotive industry faces numerous practical limitations and inconsistencies. Its implementation is further complicated by manual work (manual data entry), incomplete or fragmented data sources, and a lack of alignment with other aspects of product and process quality improvement. As a result, FMEA is often perceived merely as an administrative obligation, where the outcome of such analysis is a static document (FMEA report), most commonly exported in Excel format.

For these reasons, a number of issues arise that make FMEA, in many cases, almost ineffective, despite its fundamental purpose of ensuring a sufficiently reliable process or product in accordance with customer

requirements. Some of the most noticeable, yet serious, problems in practice include: (1) difficulties, or even the inability, to comply with standard and audit requirements, (2) inefficient use of resources, primarily time and cost, (3) time loss due to manual risk assessment (definition and updating), (4) lack of integration with Quality Management System (QMS) and Enterprise Resource Planning (ERP) systems, (5) absence of a knowledge base, resulting in a lack of traceability and duplication of data, and (6) the inability of FMEA to serve as an adequate tool for predictive analysis and the decision-making process.
There are also other issues, closely related to those mentioned, which could likewise be addressed through the application of an appropriate holistic approach. It is precisely based on these challenges that the idea for developing a SaaS solution emerged, aimed at improving and further advancing the application of FMEA in the automotive industry through the use of various tools.

3. Conceptual Framework

Based on the presented problem statement and motivation, the objective was to overcome the limitations of conventional FMEA currently used in practice. The project team is developing a system that adapts FMEA to the requirements of modern industry and transforms it into a comprehensive dynamic decision-support tool. The FMEA Excellence solution enables users to manage risks more efficiently through improved data collection, analysis, and systematization of information from existing records.
Within the FMEA Excellence platform, the traditional application and functionality of FMEA have been extended beyond technological risk assessment through the use of evolutionary artificial intelligence. In addition to conventional technological risk analysis, the platform incorporates financial, time, and strategic dimensions. This enables decision-makers to evaluate and identify optimal solutions across multiple risk aspects, ensuring that risk management activities are aligned with strategic business objectives.
In addition, FMEA Excellence applies Retrieval-Augmented Generation (RAG) integrated with large language models (LLMs), thereby enabling the creation and access of an organizational knowledge base. This functionality addresses the issue of "knowledge loss" in cases where experienced and reliable FMEA team members leave the company. Furthermore, it significantly reduces the time required to perform analyses and generate FMEA documentation.

4. Platform Overview and User Interface

The development of the SaaS solution is still ongoing, meaning that the project is currently in the implementation phase. This section presents the current version of the platform, with the aim of illustrating the user interface. FMEA Excellence is designed as a centralized and integrated platform (see Figure 2) that, in addition to FMEA, enables the use of other related quality management tools, such as process flow diagrams, control plans, task management, and continuous improvement activities.

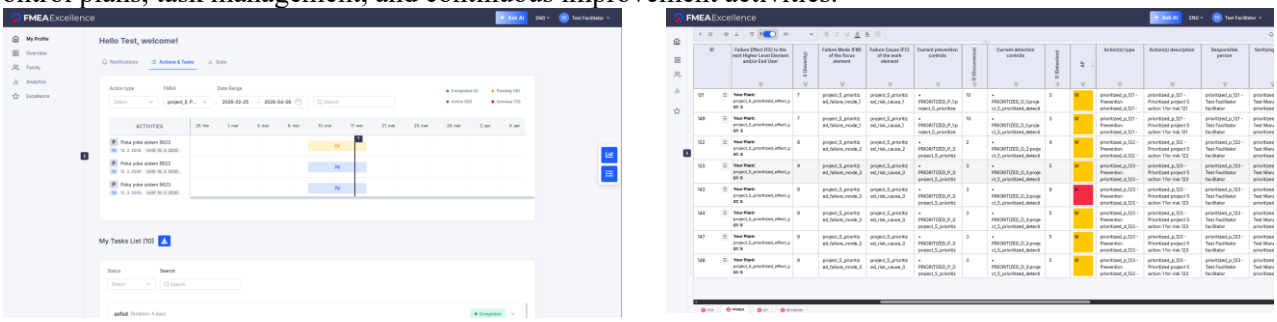

Figure 2. Platform overview: user dashboard (left) and project list interface (right)

As shown in Figure 2, FMEA is presented through a structured and visually consistent interface, encompassing all relevant elements of the analysis, including failures, causes, defined actions, risk prioritization, and related components.

5. Conclusions

This paper presents the FMEA Excellence platform development project, aimed at providing companies, primarily within the automotive industry, with a dynamic, transparent, and reliable decision-support tool. The focus is on improving the implementation of conventional FMEA as defined by the latest handbook, as well as on integrating other important aspects closely related to FMEA, primarily other quality tools relevant to the automotive industry. Although the platform is still under development, testing of some of its functionalities is already being conducted in several companies. The goal is for FMEA Excellence to become a widely recognized and broadly adopted tool in industrial practice.

Acknowledgements / Funding

The project has been supported by the StarTech program, implemented by NALED in cooperation with the Government of Serbia, and funded by Philip Morris.

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