SYNOPSYS®

A Perfect Blend of Quality in Functional Safety to Accelerate an Automotive IP Product Release

Authors

Pavithra C Suriyanarayanan
Sr. ASIC Digital Design Engineer, ARC Functional Safety Processors, Synopsys Inc.

Vijay Sardana
Sr. Staff Engineer for IP Quality Management System, Synopsys Inc.

Introduction

The automotive industry has come a long way from the invention of the gas-powered automobile in the 1860s to the present where most of us are switching to a more sustainable future and welcoming the innovation of electric-powered vehicles. Automotive technology has been around for more than a century and it isn't slowing down-there is much more to create and consume. According to McKinsey & Company, in this rapidly evolving high-disruption scenario the automotive market is more likely to achieve $6.7 Trillion in 2030 where almost 30% of the revenue will be achieved by emerging technologies. Semiconductor chip technology plays an integral role in achieving the potential. As part of the automotive supply chain, Synopsys is well positioned to provide the technology to enable the vehicles of the future.

Functional safety and quality have been two critical aspects in the automotive industry that play a major role in ensuring the safe and reliable operation of vehicles. These concepts are closely related and often overlap, as the implementation of functional safety measures contributes to the overall quality of the vehicle. However, most organizations fail to recognize this dependency and the positive impact an aligned product release can have on developing an efficient product for their customers.

Automotive functional safety refers to the measures taken to reduce the risk of harm to vehicle occupants and other road users in the event of a system failure. Quality is a broad concept that encompasses the overall performance, reliability, and durability of a vehicle. The goal of quality in the automotive industry is to produce vehicles that meet the expectations of consumers and perform safely and effectively over the long term.

At Synopsys the processor design teams have seen that balancing quality and functional safety provide efficiency in design by mitigating systematic and random faults that result from design errors, manufacturing defects, or other systematic issues that occur randomly due to environmental factors, wear and tear, or other causes.

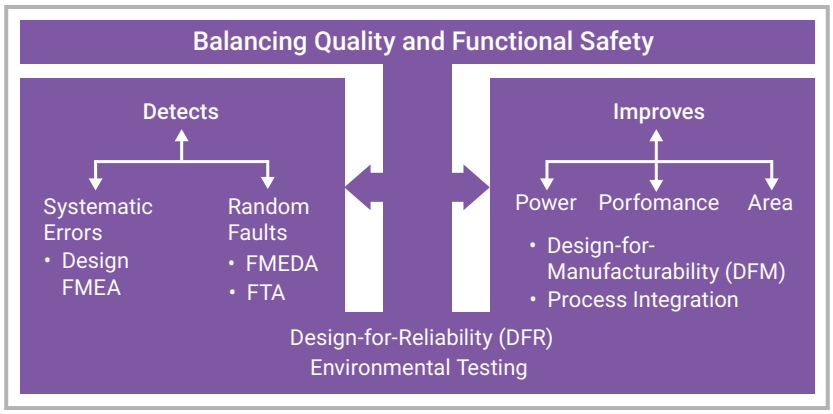

Figure 1: Methods implemented while balancing functional safety and QMS

To meet specific functional safety requirements Synopsys ARC® processor IP and Security IP adhere to ISO 26262, ISO 9001 and applicable clauses of IATF 16949 standards, where Part 10 of ISO 26262 is specific to semiconductor development. All of Synopsys' ASIL compliant ARC EM22FS and HS4xFS functional safety processors and Synopsys tRoot HSM and SPAcc Security IP products have achieved automotive compliance through third-party certification bodies adhering to functional safety and quality management guidelines.

Integration of Quality and Functional Safety

The integration of functional safety and quality into the automotive development process is crucial for ensuring the safety and reliability of vehicles on the road. Automotive manufacturers must take a comprehensive approach to both functional safety and quality, considering all aspects of the vehicle from design to production and beyond. This includes the use of advanced technologies such as simulation, testing, and data analysis to improve the design and development of vehicles, as well as the use of robust processes and systems to ensure consistent quality throughout the production process.

House of Quality and Functional Safety for Synopsys ARC Processor Product Development

Synopsys ARC processors meet stringent checks and balances that are integral for quality hardware automotive IP delivery by adhering to and translating the essence of functional safety and quality management from three main parameters into Synopsys' state-of-the-art automotive product release process. These are represented by three pillars, as shown in Figure 2.

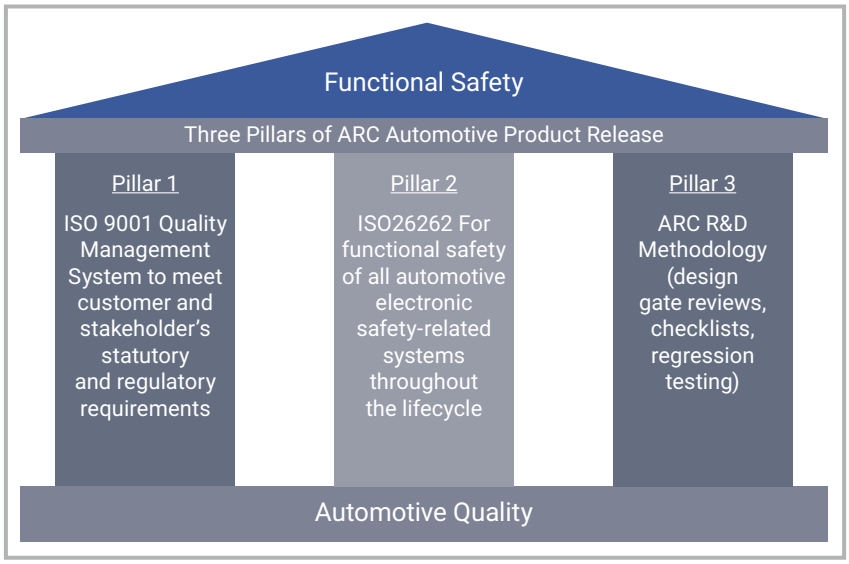

Figure 2: Pillars of Synopsys' ARC processor R&D automotive release process

Pillar 1: ISO 9001

Our organization has implemented a quality management system (QMS) based on the ISO 9001:2015 standard, and includes processes for product development, customer delivery, and supplier selection.

Synopsys' QMS is designed to ensure that all products and projects meet the highest quality standards, from conception to delivery. The key elements of the QMS are derived as per requirements of the ISO 9001:2015 standard:

- Management, Organization and Systems
- Product and project processes
- Product development processes
- Delivery of products to customers
- Supplier selection processes
- Support systems for the development and customer delivery processes

Pillar 2: ISO 26262

ISO 26262 helps us implement a functional safety development process to follow and document (for compliance) to have our IPs qualified to integrate with the customer's automotive application. We have integrated pillar 2 coherently throughout the product development lifecycle such that nominal and safety milestones are aligned effectively.

- Planning Phase: The safety requirements for the system are defined, and a safety plan is developed.
- Analysis Phase: The system is analyzed to identify hazards and potential failure modes.
- Design and Implementation Phase: The system is designed and implemented to meet the safety requirements defined in the planning phase and to eliminate or mitigate the hazards identified in the analysis phase.
- Verification Phase: The system is tested to ensure that it meets the safety requirements and that any hazards have been eliminated or mitigated.
- Validation Phase: The system is tested in its intended environment to ensure that it behaves as expected.
- Production, Operation and Decommissioning Phase: The safety requirements are maintained, and the system is decommissioned.

The validation and production, operation and decommissioning phases are tailored to the Synopsys IP development process due to its nature of being a soft IP and are replaced by the release phase.

Pillar 3: R&D Product Development Methodology

The Synopsys ARC IP R&D Product Development Methodology outlines and integrates the entire product lifecycle involving nominal and safety development. It ensures the efficient and effective development of automotive systems and components. Our methodology is based on the principles of quality and functional safety standards and is designed to support the entire product development process, from the early stages of planning, requirements capture and design to the final stages of testing, verification and release.

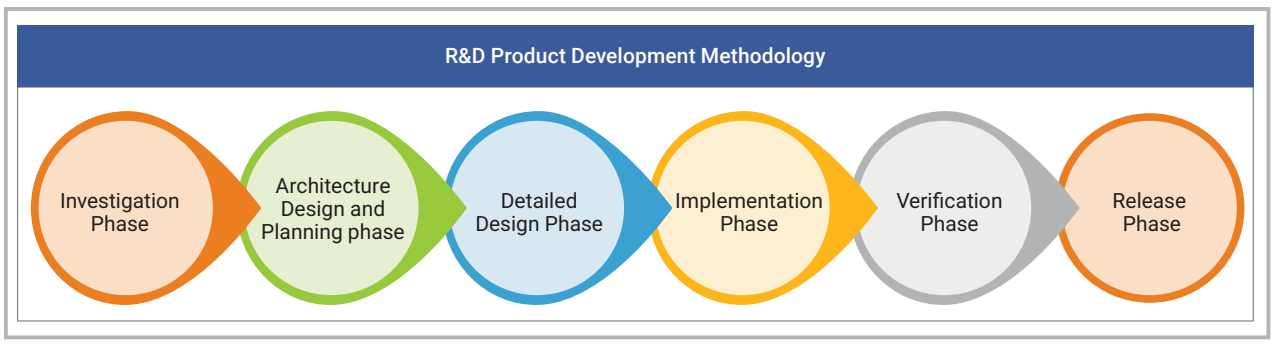

Figure 3: Phases of R&D Product Development Methodology

As depicted in Figure 3, The R&D methodology consists of the following phases:

Investigation Phase: The stakeholders define the requirements for the subsystem or component to be developed. These requirements in the form of KPIs, marketing and product requirements are captured using a model-based approach, which allows for a clear and precise representation of the system requirements.

Architecture, Design and Planning Phase: The system architecture is designed based on the requirements captured in the previous phase. The architecture design phase focuses on defining the structure and behavior of the system and its components, as well as the interactions between them. The design is then validated using simulations and other verification strategies to ensure it meets the requirements.

Verification Phase: The system is tested and validated to ensure it meets the requirements and performs as expected. This includes both functional testing and performance testing, as well as any necessary certification and compliance testing. The verification best practices include extensive evaluation of function coverages, design for testability (DFT) coverages and core reviews.

Release Phase: This phase in automotive product development is a critical stage in the process, as it involves finalizing the product design, verification traceability, release planning that includes independent FS reviews, audits, third- party assessments and confirmation reviews. By carefully managing these activities, organizations can ensure that their automotive products meet customer requirements, regulatory standards, and quality and safety requirements, leading to successful market launch and customer satisfaction.

Lessons Learned: In the final phase the lessons learned is conducted post release to emphasize the importance of early detection of issues, effective communication, compliance with regulatory standards, continuous improvement, and customer feedback. By focusing on these key areas, we improve our product release processes and deliver high-quality products that meet customer expectations.

The R&D methodology provides a structured and systematic approach to the development of automotive systems and components, which helps to ensure the efficient and effective development of high-quality products. By using a model-based approach, the product development methodology Synopsys employs for ARC processors allows for a clear and precise representation of the system requirements and architecture, which helps to minimize the risk of errors and ensure the development of high-quality products that meet the needs of the stakeholders.

Managing Quality and Functional Safety in all Phases of Product Development

The development of Synopsys ARC processors considers the Synopsys Solutions Group's functional safety development process, its product development process, and all key supporting QMS processes and quality tools as explained below in Figure 4 and 5.

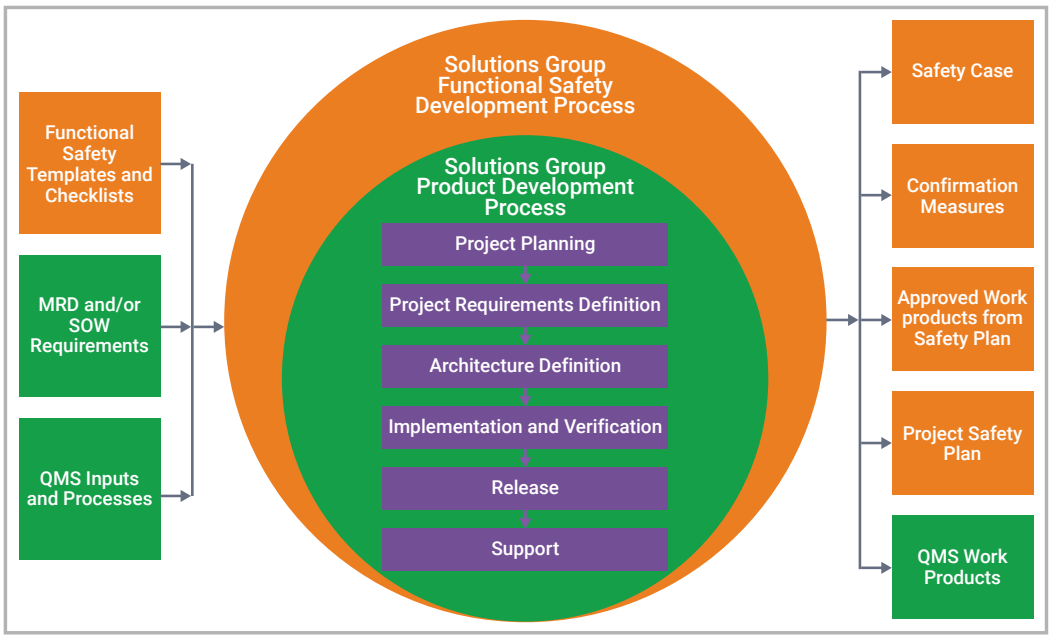

Figure 4: Functional safety development process framework implemented in the development of ARC processors

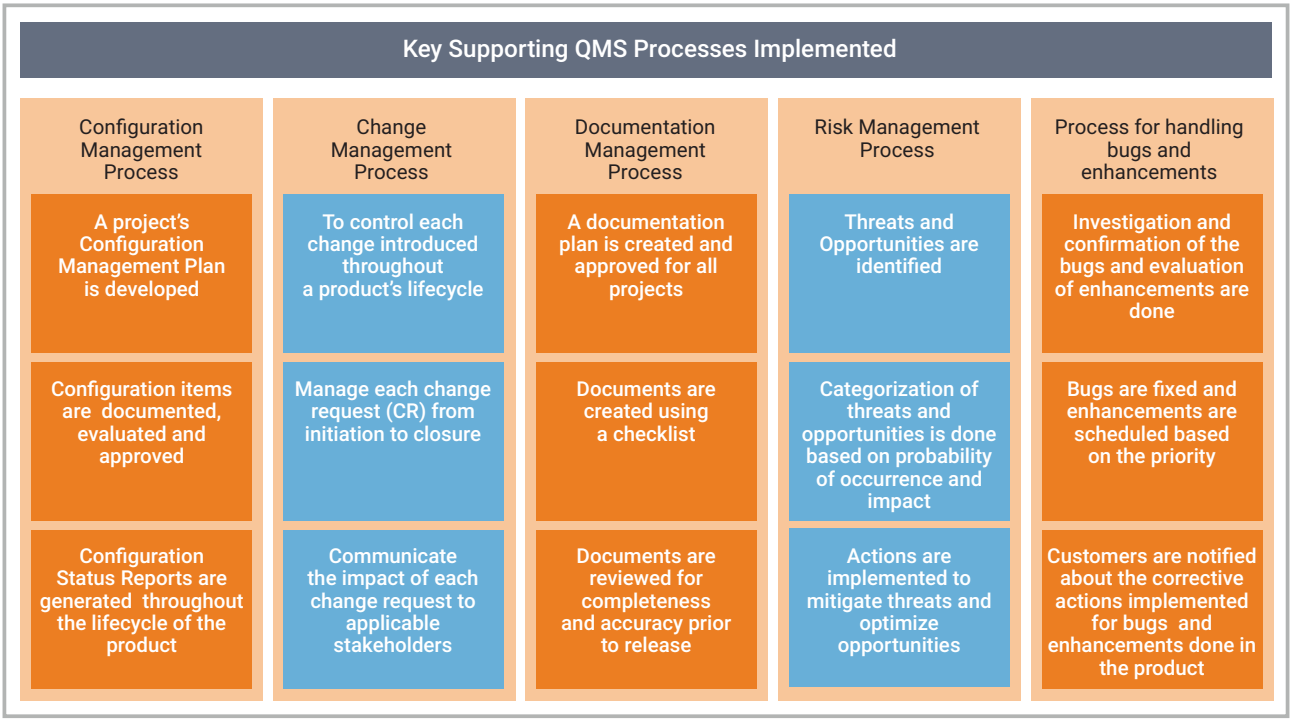

Figure 5: SG Quality Management Process Framework implemented in the development of ARC processors

Requirements Management Tool:

All stakeholder requirements documentation, analysis, review, approval, and traceability is managed through a Requirement Management Tool for both nominal and safety. Requirement management during our product development includes the process of defining, documenting, and tracking the requirements.

Similarly, **requirement traceability** refers to the ability to track the relationships between requirements and the related design, development, verification, and delivery activities.

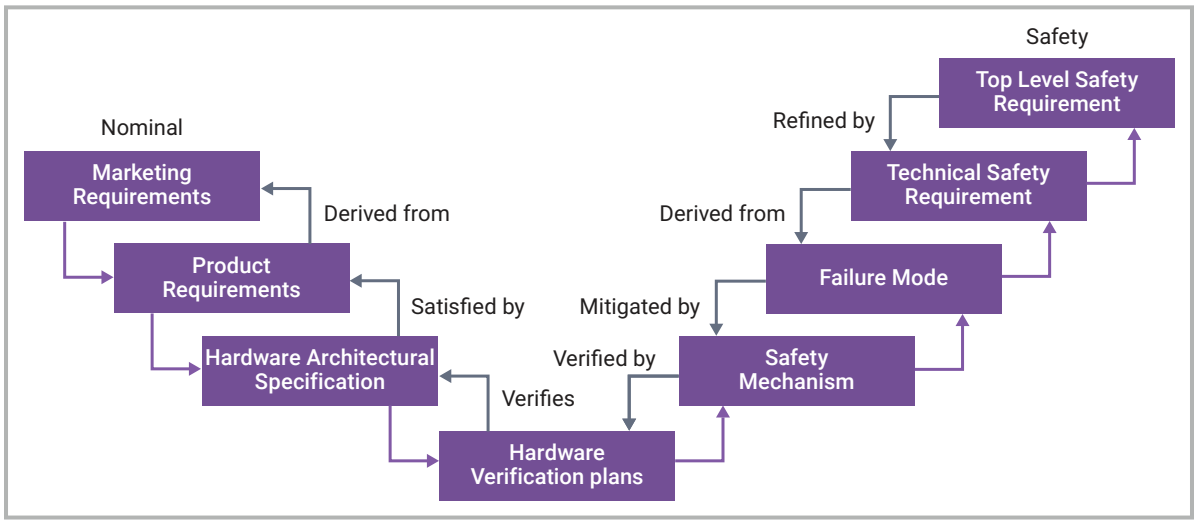

Figure 6: Requirement traceability for nominal and safety requirements in the product development

In our product lifecycle, requirement traceability is particularly important due to the complex and regulated nature of the products being developed.

Issue Tracking and Project Management Platform

A robust project management tool is used when developing Synopsys ARC processors that helps our key stakeholders efficiently drive throughout the entire product development lifecycle. Issue tracking is an essential part of the QMS in the automotive industry. Here are some key considerations for implementing issue tracking as part of our product lifecycle:

- **Define the issue** clearly and specifically, including the root cause and potential impact to ensure that the issue is properly addressed and resolved.
- **Assign responsibility** for addressing the issue to specific individuals or teams or establishing a cross-functional team to address the issue.
- **Set priorities** for addressing issues based on their potential impact on safety, quality, and customer satisfaction. This may involve establishing a system for categorizing issues by severity and allocating resources accordingly.
- **Track progress** on addressing the issue, including key milestones, timelines, and outcomes to ensure that the issue is properly addressed and resolved in a timely and effective manner.
- **Conduct root cause analysis** to identify the underlying causes of the issue using tools such as the 5 Whys, fishbone diagrams, or Pareto analysis.
- **Implement corrective and preventive actions** to address the issue and prevent it from recurring in the future by making changes to processes, procedures, or systems to address the underlying causes of the issue.

Overall, effective issue tracking is essential to the success of the QMS in the automotive industry. By following these key considerations, automotive organizations can ensure that issues are properly addressed and resolved, and that corrective and preventive actions are implemented to prevent similar issues from occurring in the future.

Quality Checklist Tool

The Quality Checklist Tool is a natively designed and developed browser-based system for housing and smoothing the way of performing the checks and balances for managing all project releases. All SG R&D teams are required to complete the applicable checklists in the tool for their specific product family. Upon completion it is shared with key stakeholders that are authorized to validate and approve the product for release (Figure 7).

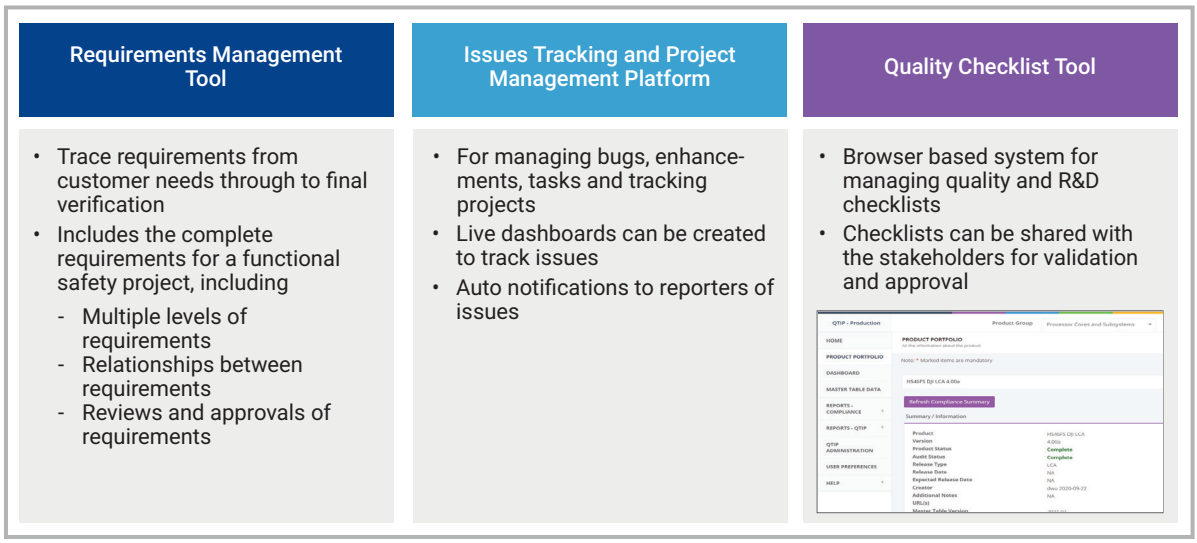

Figure 7: Summary of quality tools involved in automotive development process

Conclusion

The perfect blend to automotive quality and functional safety implemented in our product development lifecycle that qualifies our automotive products to release has proven benefits to our customers, as shown in Figure 8.

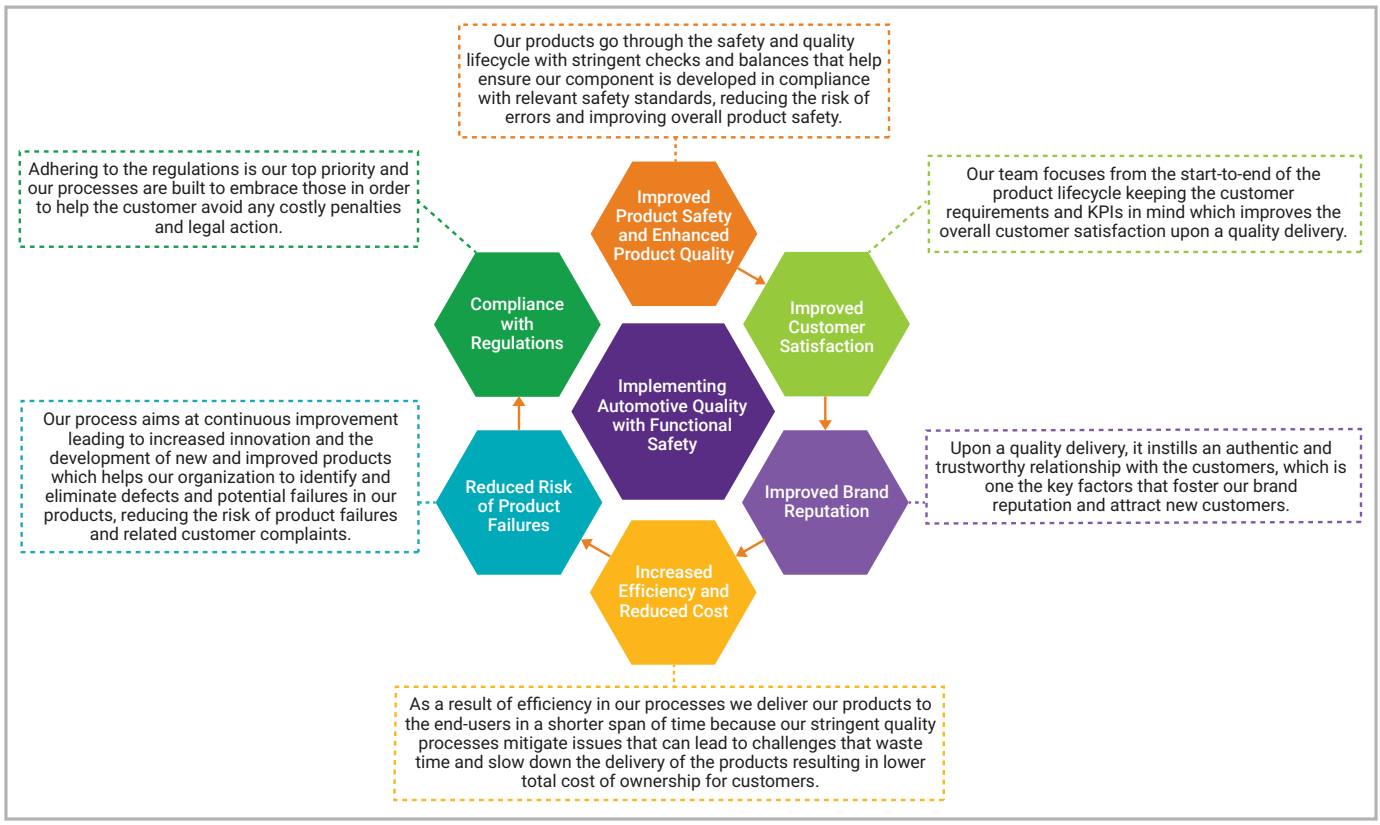

Figure 8: Benefits of a product development lifecycle with integrated quality and functional safety processes

Overall, the automotive industry has come a long way in terms of safety and quality. Today's cars are much safer and more reliable than those of the past, thanks to advances in technology, materials, and manufacturing processes. However, there is always room for improvement, and automakers continue to work on developing new safety and quality features for their cars. Be it a hybrid, electric, gas or diesel vehicle, the ISO 26262 safety standard and the ISO 9001 quality standard implementation is unbiased regardless of technology. The common element among these is the embedded 'semiconductor' technology that drive the functionality.

In conclusion, implementing quality and safety in products has proven to be necessary for the manufacturing industry because it ensures the consistency of the products delivered to the end consumers. It also guarantees that the products manufactured comply with the standards specified in the industry. And in the automotive sector, this is of utmost importance because substandard vehicle parts may lead not only to damage to property but to loss of lives as well.

References

1. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/disruptive-trends-that-will-transform-the-auto-industry/de-DE
2. ISO 9001:2015 Standard
3. ISO 26262-2018 Standard

08/02/23.CS1159417306-describing-ARC-functional-safety-WP.

Pub: July 2023