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# Quality in the Future of Manufacturing

The dawn of digitalisation and high competitive business environment make a compelling case for a holistic quality management approach in discrete industries

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A Frost & Sullivan Whitepaper

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## EXECUTIVE SUMMARY

Quality has often been an aspect heavily talked about but scarcely invested. This rings true across many contexts, but it is most evident in the sector of manufacturing. In our research that involved a large spread of end-users, we have been indicated time and again that quality is a key criterion but one that always falls lower in priority when compared to other KPIs like cycle times, lead times, and production efficiency. Additionally, the value of quality is understood but the cost of quality, at most times, is not sufficiently managed. Most of the times there is no intentional decision to avoid quality management but the cost of quality or the change needed to enable a proper CLQ is difficult to be pursued. The issue of quality has thus been acknowledged widely but it has not been explored in depth.

This white paper was aimed at establishing an in-depth analysis of the quality paradigm for manufacturing. For the benefit of depth, we have tried to focus on two specific industries- automotive and industrial machinery & heavy equipment. We have tried to assess the impact of poor quality in these two verticals and provided a basis on why quality management merits top priority. The other objective has also been to highlight the need for a systematic approach when it comes to implementation.

In our research, we inferred that the benefits of good quality management are grossly under-rated. For instance, a good quality management approach not only results in higher productivity, but also less downtime, minimal rework, a spike in sales and improved employee productivity. It is evident that there are still margins to improve quality and related quality costs. However this trend is beginning to change. To support this point, we took the quality management systems (QMS) market as an indicator – discerned vital market intelligence statistics that reflects a growing appetite for efficient quality management practices. But the QMS market is not without its challenges. A lack of clarity on the benefits and RoI (return on investment) presents itself whenever the idea of QMS is brought for discussion. A part of the issue here has been from the end of suppliers.

The challenge that we find in the supplier market of quality solutions is two-fold. On the one hand, suppliers do not have a cogent QMS solution that fits the need for end-users. On the other hand, the QMS approach of many suppliers is best-of-breed and exclusive. The second challenge is possibly the most potent roadblock that currently exists within the industry. We can be certain that a good quality management system will only be fully effective, if and only if it is implemented as a part of a larger PLM strategy.

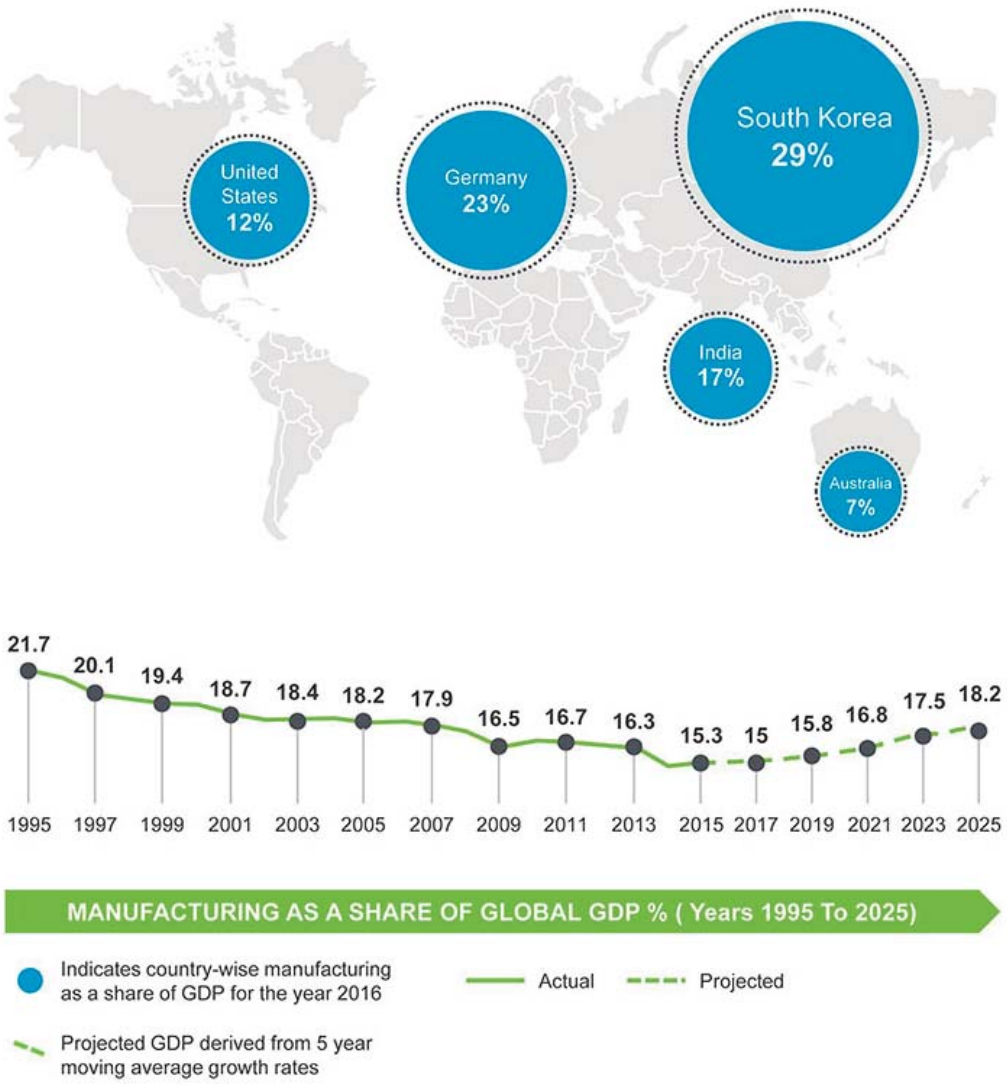
The onset of digitalisation trends in manufacturing will further exacerbate the quest for finer quality. Going forward, we are certain to see quality gaining a larger share of end-user investment than ever before. In other words, quality will cease to be an after-thought and transform into a quintessential part of operational strategy in the factories of tomorrow.

## INTRODUCTION AND CONTEXT

The manufacturing industry of today's connected world is light-years beyond where it was a century ago, no longer characterized by grimy factory conditions or strictly reserved for a blue-collar workforce. Transformations have taken manufacturing from producing simple goods to delivering increasingly complex and technologically advanced products across numerous verticals, including major sectors such as the automotive (along with their suppliers) and the industrial machinery and heavy equipment (IM&E) industries. In essence, manufacturing has undergone several technological upgrades of its processes, talent, and production capabilities.

Global output of manufactured products, however, is advancing at a slow pace. According to World Bank statistics, manufacturing as a share of global GDP has declined from 21.7% to 15.3%[1] within a span of 20 years. Frost & Sullivan expects a reversal in this declining trend as the GDP is expected to slowly start growing from 2017 and touch around 18.2% by 2025. Exhibit 1 illustrates this activity, highlighting 5 main countries.

**Exhibit 1: Manufacturing Share of GDP (%), Global, 1995 to 2025**




*Source :World Bank; Frost & Sullivan Analysis*

There are compelling forces behind the decline up to 2015. Market restraints such as political instability, low volume of foreign trade, increased import duties, and emergence of new nationalist movements are impeding the free movement of goods in the manufacturing value chain. Yet, emerging technological trends are transforming the industrial landscape.

With the advent of Industrial Internet of Things (IIoT) and global manufacturing initiatives—such as Industrie 4.0, Make in India, and Made in China 2025—manufacturing is regaining importance across regions and will soon offer a competitive edge in contributing to the overall global GDP.

### *Manufacturing Objectives*

- *Remain cost competitive*
- *Maximize profits*
- *Ensure speedy delivery*
- *Improve customer satisfaction Accelerate growth*

In particular, digitization has transformed the way goods are being manufactured. Key to this evolution is the convergence of several current information and communication technologies (ICT) such as mobile devices, social networks, cloud computing, application platforms, and analytics and cognitive technologies with operational technologies (OT) such as sensors, robots, and additive manufacturing. Digital twin is a path breaking technology that is redefining the design and manufacturing processes. Rapid advances in computer science have enabled the development of digital twin to develop new products of high quality and be able to deliver these products to the market much faster than ever. It can come a long way in helping manufacturers in reduce product defects and production costs and be able to eliminate nearly all risks in future products.

The convergence of technologies from the best of both the worlds—IT and OT—is exemplified in IIoT. This powerful combination has conferred upon manufacturing the revolutionary potential to customize, predict, and diagnose impending machine or process failures; improve efficiencies; and boost productivity by as much as 40%.

Nevertheless, not all manufacturers have embraced the digital transformation, and a majority remains hampered by significant quality-related challenges. Some of the quality issues that are common across major manufacturing verticals globally, specifically in the automotive and IM&E sectors, are outlined in exhibit 2.

**Exhibit 2: Common Quality Issues across Manufacturing Verticals, Global, 2017**

| Quality Issues | Level of Importance | | |
|---|---|---|---|
| | Automotive | Industrial Machinery | Heavy Equipment |
| Maintaining consistency of product quality across all manufacturing stages | High | High | High |
| Arriving at a definite RoI from QMS implementations | High | High | High |
| Fixing quality issues before they happen | High | High | High |
| Compliance to emission and other industry regulations | High | Medium | Medium |
| Ensuring faster time to market | High | Medium | Medium |
| Need for visibility of quality across the entire manufacturing value chain | High | Medium | Medium |
| Real-time alert and traceability of quality issues across different regions and plants | High | Low | Low |
| Need for a closed looped quality management system that can help connect performance data between different areas of the manufacturing value chain | Medium | Medium | Medium |
| Adapting to dynamic customer requirements | Medium | Medium | Low |

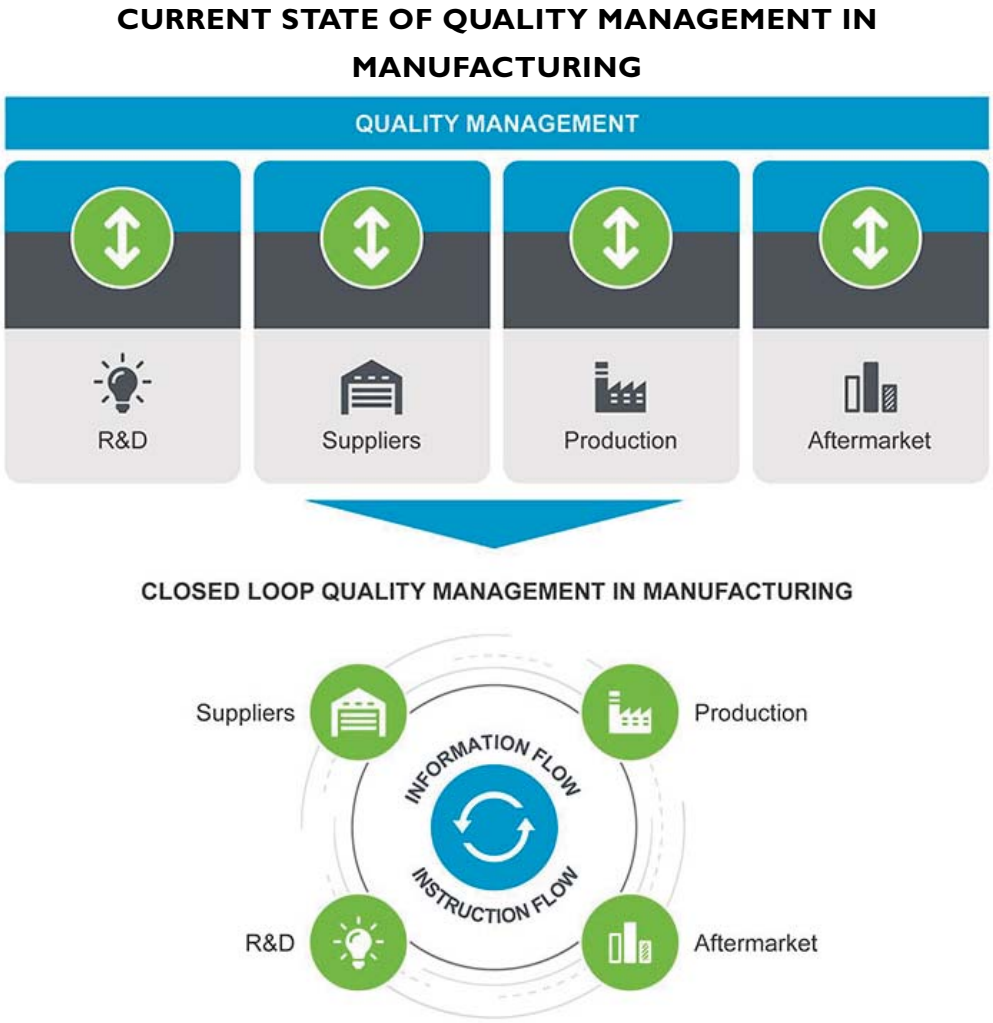
*Source: Frost & Sullivan Customer Research*

In order to best mitigate these quality issues, a strategic approach to quality management is necessary. As manufacturers continue expanding their operations globally, companies are being forced to be digitally connected and follow an integrated approach toward industrial process management. In addition, improved trade and related bilateral trade agreements create opportunities for companies to establish operations globally, whereas focused manufacturing initiatives help improve the share of GDP in manufacturing for Brazil, Russia, India, and China (BRIC). Each of these factors leads to an increased demand for systems and software that support cross-border manufacturing operations. That said, most companies today still follow a siloed approach to quality management, but a closed-loop quality management system (QMS) is needed to enable a bidirectional flow of information to and from the departments across a global manufacturing value chain.

In the current stagnated economic growth scenario, productivity gains are pre-eminent. Industrial producers will do well to probe into innovative technologies and tools that can help integrate customer operations into their systems, and, concurrently, help improve process efficiencies, bring down production costs, and boost factory performance.

To achieve this, manufacturing organisations are making strategic investments in quality management solutions. Exhibit 3 illustrates how the traditional quality management set-up in manufacturing is increasingly making a move towards the more future-ready closed-loop approach.

**Exhibit 3: Transforming Quality Management in Manufacturing**




*Source: Frost & Sullivan Analysis*

The closed loop quality management, in essence, means connecting quality performance data from one manufacturing department to another. It also involves using or re-using the digital twin model and real data to implement an improvement cycle where all stakeholders contribute to further improve and fine tune a product, thereby reducing risk of failures and containing quality costs. This is known to have a positive impact on the overall quality of manufacturing. Some of the other major factors that are expected to have a meaningful impact on quality in manufacturing are presented in exhibit 4.

**Exhibit 4: Forces Driving Quality in Manufacturing**


*Source: Frost & Sullivan*

Compounding the benefits of a closed loop quality management approach are the above mentioned forces that drive quality in manufacturing at both an organization and an industry level. To further remain competitive, manufacturers must improve the quality of their existing processes and products. This will help cut down on wastage and re-work costs, not to mention the effort and time involved in responding to these and all quality-related issues while increasing customer satisfaction as ultimate goal. With companies becoming increasingly connected, however, the process of managing quality becomes more strenuous.

As the boundaries between production and management continue to fade, it is imperative that quality management systems be integrated across all functions of industrial operations so organisations can fully tap the potential of smart manufacturing.

## QUALITY IN MANUFACTURING: A GROWING PROFIT CENTRE

Quality is no longer synonymous with product integrity alone; instead, it is a company's on-going commitment to excellence across all departments, individuals, and processes involved in developing the product (including sustainability, regulatory requirements, quality enforcement, cost reduction and efficiency, prevention of failures, standard reporting, lessons learned and know how transfer, etc.). For a customer, quality boils down to choosing the most optimal solution that will materialize their desired outcomes, ensuring the highest level of quality throughout the product's lifecycle. Traditionally, companies have manually managed quality internally, relying on in-house quality teams that mostly use static documents or isolated applications for quality management tracking. But, over time, businesses felt the need for something more robust to manage their ever-expanding and increasingly complex business requirements. This shift has given way to smarter modes of managing quality in the form of QMS.

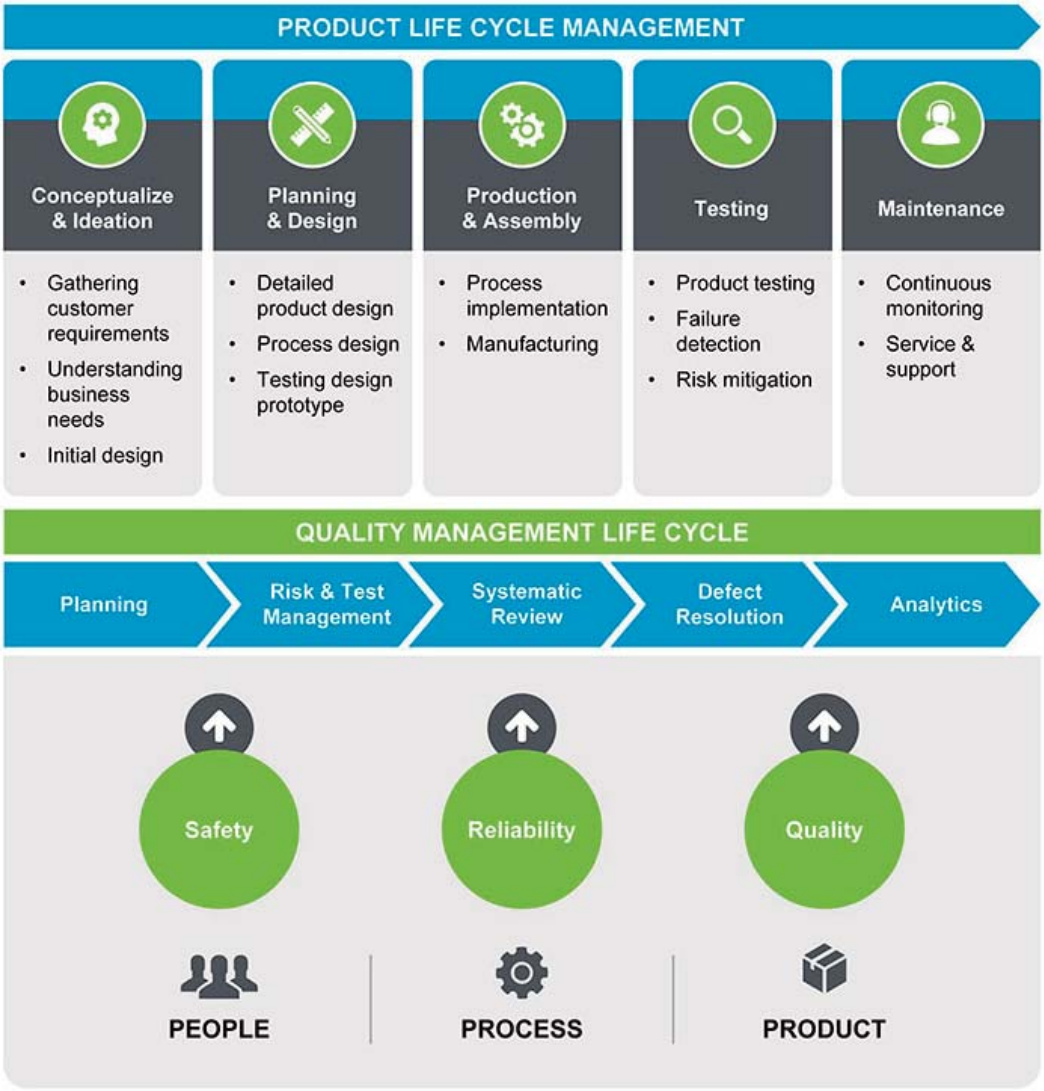
QMS suites, are contained in software that include a structured collection of business objectives, policies, procedures, and principles dedicated to ensuring customer requirements are met, regulations and norms are respected and improvement tools are implemented to reduce cost and manage quality efficiently. The systems are integrated so that they work harmoniously as one. Of course, the policies, procedures, and work instructions are properly documented. This software also provides a framework that can perform data analysis, monitor and measure performance, and complete audits that adhere to process requirements. A documented outlook to quality management helps ensure efficient administration of product and process quality through proper guidance of professionals at all management levels and across all departments of the organisation.

Ensuring quality, safety, and reliability of product, people, and processes across all stages of product life cycle is thus an inherent part of any business objective and quality principle.

QMS, when integrated with other manufacturing control systems such as manufacturing execution systems (MES), enterprise resource planning (ERP), customer relationship management (CRM), or product life cycle management (PLM) can effectively streamline manufacturing operations by ensuring adherence to quality norms at all stages of product and process life cycles. This integrated approach supports the smooth flow of information across all process modules and departments of the organisation. In fact, QMS empowers organisations with the freedom to create touch points throughout the entire value chain that can enable cross-functional collaboration and communication. Ideally, therefore, QMS should not be regarded as a separate department vis-à-vis other manufacturing control systems.

Following a life cycle approach to quality management help organisations make quality a shared responsibility instead of treating it as a disconnected concept. By following this connected approach, one can delivers solutions with greater consistency, efficiency, accuracy and predictability. Quality management should therefore be necessarily integrated across the different stages of the product life cycle as illustrated in exhibit 5.

**Exhibit 5: Life Cycle Approach to Quality Management**

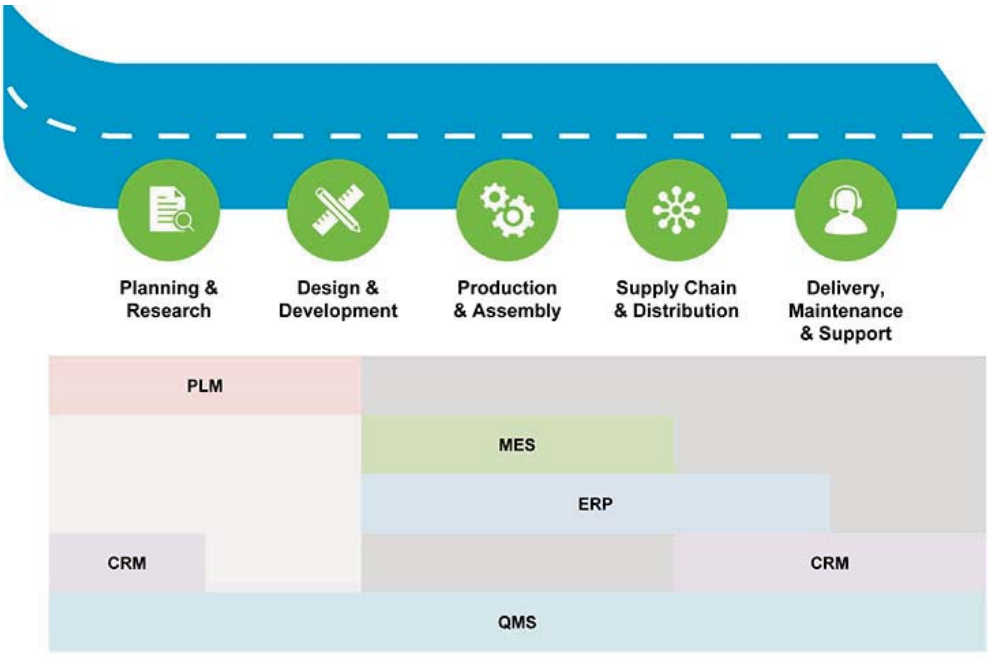



*Source: Frost & Sullivan*

By following the above approach, organisations can deliver better products and solutions, thereby exceeding customer expectations resulting in increased sales, customer retention and overall manage costs being more efficient than competition. Ensuring quality across all stages of the product life cycle can also help organisations in effectively bringing down the time-to-market and cut down risks due to complexities that exist in the manufacturing value chain.

A successful QMS will bridge and integrate all departments of the manufacturing value chain. A systematic and integrated approach to managing quality helps manufacturers gain overall visibility into manufacturing and develop actionable intelligence to proactively diagnose and prevent potential quality-related failures. As a result, manufacturers will benefit from reduced time-to-market, enhanced flexibility, improved traceability, decreased wastage, minimal re-work, and better efficiency. All of these process improvements translate into healthy revenue gains for manufacturers. Some of the key areas of the manufacturing value chain where QMS can find the right fit are presented in exhibit 6.

**Exhibit 6: Finding a Fit for QMS in the Manufacturing Value Chain**




*Source: Frost & Sullivan*

From the above exhibit, it is evident how the benefits of QMS can be derived across all stages of manufacturing value chain - right from the planning and research of products to its final delivery, maintenance and support related activities; which is why investing in the right QMS could be considered as one of the key strategic investments for any organisation.

## Deriving QMS Value

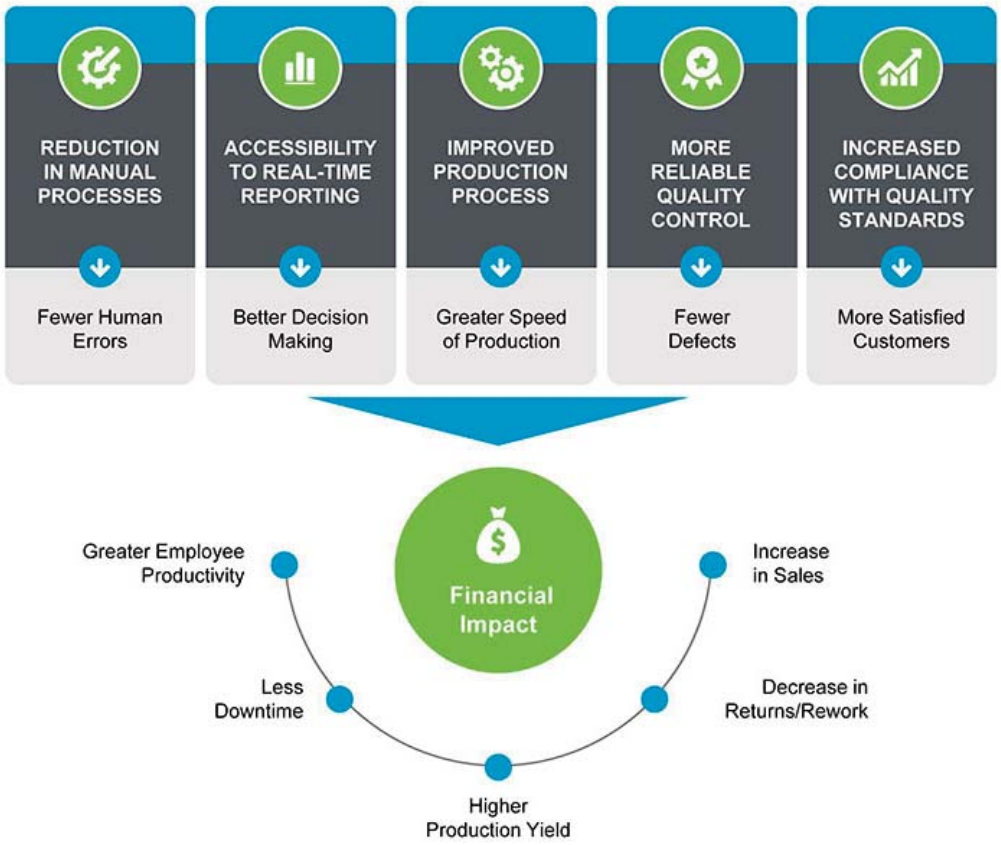
Irrespective of the size or nature of a company, a well-designed QMS helps to maintain a standard set of protocols on how key processes are overseen and managed. Consistency, moreover, is a cornerstone of quality management. All processes and product stages—from design and development to shipping and delivery—are guided by a set of quality principles. Following a consistent approach to quality management creates an environment prepared to reduce the occurrence of errors.

The ability to accurately map product design according to unique customer needs should be one of the objectives of a QMS. From the manufacturer's perspective, a well-designed QMS can help meet customer requirements and undertake a transparent approach to all activities. This can instil confidence among customers, which, in turn, leads to repeat business, new customers, and, ultimately, higher sales figures. Essentially, a correlation exists between stringent process control and consistency of performance. As a result, fewer product re-calls and lesser material waste are recorded. This further helps avoid unnecessary costs and boosts productivity.

Among the several questions that manufacturers have asked technology providers, the most prominent ones include: What impact will implementing QMS have on my organisation? Where should we target our investments? What are those quality management capabilities that can help us do better?

The following exhibit 7 is an attempt to provide answers to these questions and give an indication of the possible economic impact that a well implemented QMS can have on manufacturing.

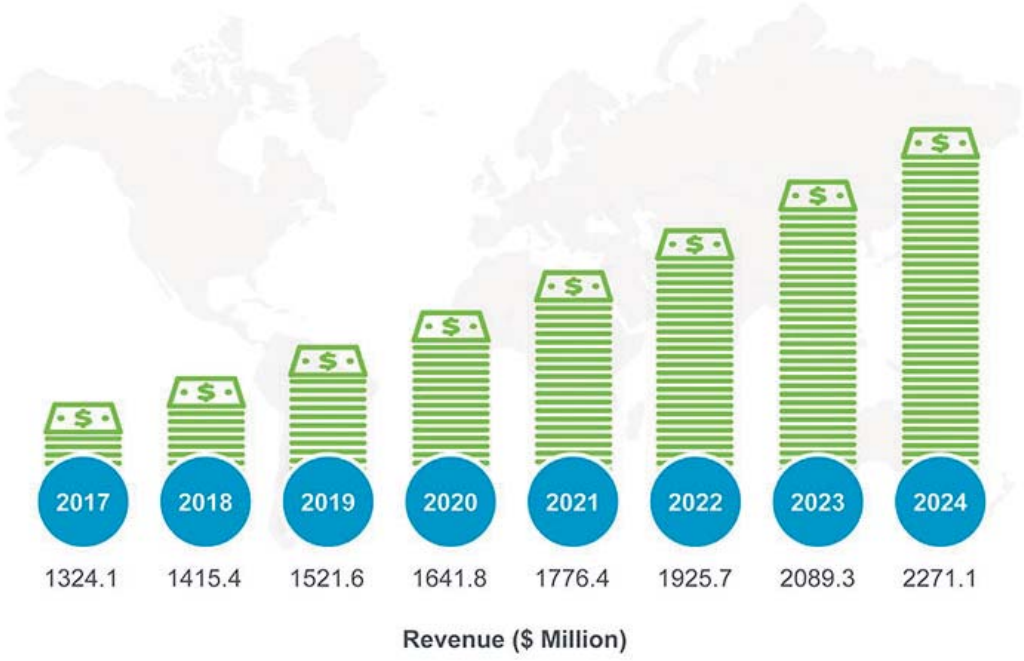
**Exhibit 7: Financial Impact of QMS in Manufacturing**




*Source: Frost & Sullivan*

The QMS can thus come a long way in helping organisations improve the efficiencies of their manufacturing processes, reduce costs and rework and improve manufacturing productivity. This in turn can have a positive impact on the financial status of the organisation. Globally, the overall QMS market is expected to grow at a CAGR of 8% by 2024. The growth pattern of the QMS market is as illustrated in the exhibit below:

**TOTAL QMS MARKET: REVENUE FORECAST, GLOBAL, 2017–2024**
**CAGR(2017-2024) = 8.0%**




*Source: Frost & Sullivan*

Despite all the benefits, there are still some challenges that companies would need to overcome in order to completely tap the benefits of a QMS.

### Current Roadblocks

Even though quality management is an integral part of all aspects of the manufacturing value chain—from planning and design to production, supply chain, and customer delivery and support—several quality professionals conclude that quality management is not well represented in manufacturing. This view is a result of several impending challenges that complicate the manufacturing ecosystem.

The world is at the brink of a 4th Industrial Revolution that will fundamentally refocus the current perception of quality in manufacturing and rewrite the traditional management approach. With the surge in number of connected machines already disrupting the status quo, manufacturing businesses are developing complex global networks of suppliers and customers. This trend is spreading and will increase in intensity.

As the manufacturing industry learns to equip itself with IIoT technology, a disparity will surface between legacy and cutting-edge systems across organisational quality programs. Consequently, guaranteeing compliance to product and process quality stipulations and standards has become challenging between stakeholders operating off of disparate systems, divergent process metrics, and different production schedules. A stand-alone quality management department or application will, therefore, no longer suffice in catering to the dynamic and discordant industry conditions.

With competition intensifying across manufacturing industry sectors, pressure continues to mount among companies vying for supremacy and fighting to deliver flawless products within the shortest time to market. Further, volatile business demands and changing customer requirements will result in customization-on-the-go, which will make production process and quality management all the more onerous.

Industries such as automotive manufacturing are constantly under pressure to abide by new regulations. This is a highly demanding industry that does not spare the occurrence of errors in any form at any stage of the manufacturing value chain. Manufacturers are forced to tread with caution, as any quality issue could result in complete product failure and a tarnished brand image. As in every other manufacturing industry, it is essential for manufacturers to understand that quality management does not end with delivering the product to the end customer, especially with the introduction of IIoT and other advanced manufacturing technologies that are changing quality measuring metrics. Companies will bode well to re-assess their quality management procedures sooner than later.

As more and more businesses expand globally, and with the addition of an increasing number of stakeholders, securing an end-to-end view of quality management becomes more difficult. Nonetheless, manufacturers are under constant pressure to fulfil deliveries, sometimes within unreasonable timelines. This pushes some companies to create products that are non- or not fully compliant with quality standards because they resort to ad-hoc troubleshooting measures, which leads to failed quality standards.

When companies do attempt to comply with standards, corrective and preventive action reports from quality personnel are often misplaced within the complex value chain and processes, which impedes manufacturers from making proper decisions. Getting the right data, from the right place, and at the right time, therefore, is crucial to the success of a manufacturing business. Yet every business is unique, so a one-size-fits-all solution cannot solve these problems. This is why quality management solutions must be flexible and able to align with a company's unique business needs.

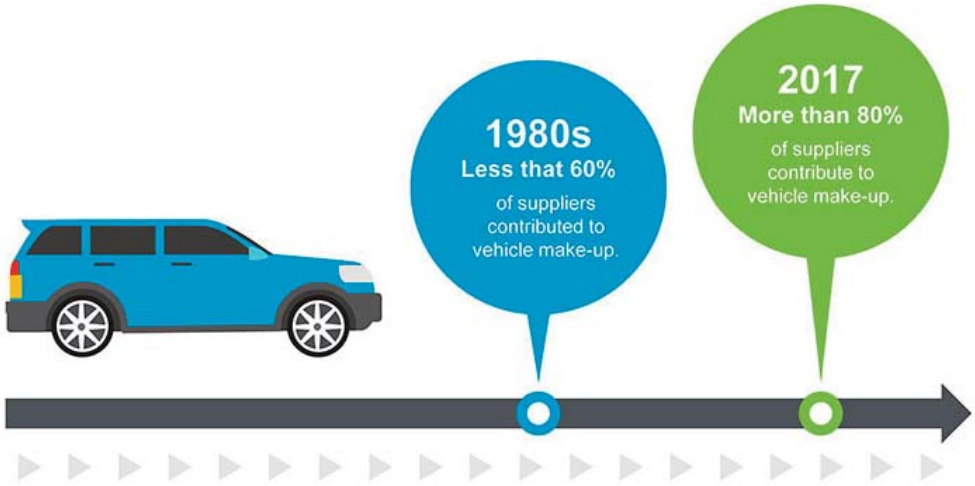
Quality administrators must come up with the right strategies that will account for all value chain and process-related challenges. A centralised and streamlined solution such as a QMS can help manufacturers overcome these issues by integrating the different internal processes and systems. According to recent Frost & Sullivan research, 80% of manufacturers globally are expected to adopt IIoT by 2021. To facilitate this transformation, companies are in the process of initiating new policies and setting up quality frameworks around IIoT. To a large extent, a QMS can deliver a clear direction and an organized set of protocols that manufacturers can abide by to ensure smooth operations and quality deliveries. A process-enabled QMS will give manufacturers the power to close existing gaps, as well as identify, measure, control, and improve business processes. This type of future-ready system, therefore, will become the common denominator of industrial advancement.

## QMS for the Automotive Industry

The automotive industry is characterized by its dynamic and uniquely complex and expansive supply chain network. Numerous stakeholders are involved at every stage of the manufacturing value chain, including four or more levels of suppliers, original equipment manufacturers (OEMs), dealers, and customers. Locating the origin of an auto part defect can prove daunting. A typical car has about 30,000[2] auto parts, all delivered to the OEM by various auto part suppliers. Additionally, a single auto part is sometimes offered by multiple suppliers, and one supplier may source multiple components to several different OEMs at the same time. In such a scenario, it can get extremely difficult for the OEM or the supplier to manually keep track of the high volume of parts moving in so many directions.

Traditionally, quality concerns rested with the OEMs alone, but today the responsibility is changing with suppliers now sharing the burden. The following exhibit 8 illustrates the growing importance of suppliers in the manufacturing value chain and how this changing the manufacturing scenario.

**Exhibit 8: Evolving Importance of Suppliers in the Manufacturing Value Chain**




**What does this change mean?**

- Suppliers are getting bigger.
- Growing complexity in supplier network as a result of manufacturers engaging multiple suppliers for the same component.
- Suppliers become a critical part of the manufacturing value chain.
- Failure at even tier 4 supplier level can disrupt an assembly line operation.
- Suppliers have huge financial stakes: assembly line downtime can cost as much as $1.25 million / hour.

**What could be the way forward?**

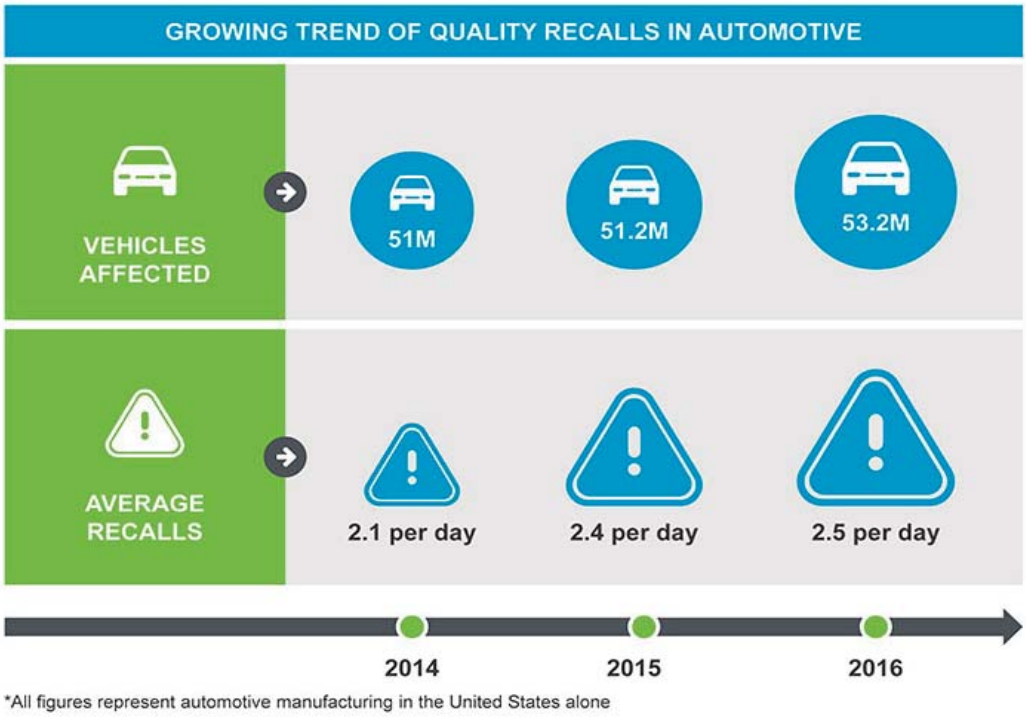
- Standardization of manufacturing processes, systems, operations and skillsets.
- Smarter quality management.
- Risk-balanced supply chain.
- Smarter visibility and traceability.
- Effective collaboration across all supplier tiers.

*Source : DHL; Frost & Sullivan*

There is therefore a growing importance for QMS software that can understand this dynamic supplier market and be able to deliver effective solutions that could result in smarter product life cycle and quality management. In high-risk industries such as the automotive, companies can face staggering repercussions from product failures. Quality has been the prime cause for a large number of product recalls. Historically, loss of reputation or a smeared brand image resulting from the failed quality of a product has been massive and is made worse by a sharp drop in stock prices as shareholders lose trust in the company. Further, the affected company would suffer legal hassles and financial hardships, a setback that takes several years to recover from. In some instances, companies have not been able to regain what was lost.

According to the National Highway Traffic Safety Administration (NHTSA), automakers were forced to recall 53.2 million[3] vehicles in United States in 2016 alone owing to negligence and quality-related issues. These recalls translated into revenue loss of several millions of dollars and also resulted in loss of business reputation and goodwill.

**Exhibit 9 is indicative of the growing trend of quality recalls in the automotive industry over the past three years.**




*Source : NHTSA*

As shown in the exhibit above, the number of quality recalls has been soaring steadily since year 2014 alongside a growing automotive industry. The increasing use of auto components along with the increasing number of suppliers in the automotive ecosystem has resulted in a mass recall activity following a faulty auto part or software problem. Added to this are the stringent regulations by regulatory bodies such as NHTSA and peer media pressure, that has resulted in auto makers proactively identifying potential issues and initiating the recall activity.

The table in exhibit 10 presents a sample of highly recalled auto supplier parts in the last two decades.

**Exhibit 10: Highly Recalled Auto Supplier Parts in the Past Two Decades**

| Recalled Auto Part | Number of Parts Recalled | Impacted OEM |
|---|---|---|
| Safety Catch | 21 million | Ford |
| Ignition Switches | 1.62 million | General Motors |
| | 8.7 million | Ford |
| | 5.87 million | Chevrolet |
| Cruise Control Switches | 14 million | Ford |
| Gas Pedal (Accelerator) & Floor Mats | 10 million | Toyota |
| Airbag | 0.8 million | Mercedes-Benz |
| | 5.4 million | Honda |
| Fuse | 2.1 million | Mercedes-Benz |

*Source : Forbes; iSeeCars, Yourmechanic, Investopedia*

In some of these auto recall incidents, not all of the vehicles would have been supplied with defective auto components. For instance, in a batch size of 5,000 auto parts, perhaps only 50 were defective. But without proper traceability, these 50 defective auto parts would get mixed up with the good components. Consequently, the OEM would be forced to recall all vehicles that had those 5,000 auto parts from a particular supplier.

This scenario could lead to severe financial and rework losses for both the OEM and the supplier.

Therefore, manufacturers are in significant need of a smarter way to track all product parts that go into the making of their automobiles. Although the suppliers provide vehicle parts such as brakes, tyres, airbags, or lights, they depend upon their sub-contractors to source these part components. In such a complex web of OEMs, suppliers, and sub-contractors, the need for a centralised system that can help keep track of faulty machine parts and also help in ascertaining failures wherever possible is an outstanding and pervasive need.

**The Power of Today's Informed Consumer**

OEMs and suppliers are under constant pressure to innovate and sustain high-quality products. This gets even more difficult when factoring in dynamic consumer requirements. Consumers are becoming increasingly powerful and influential in the automotive industry, which, in turn, is generating a new set of risks and potential rewards for suppliers. The impact of this change is directly felt by the suppliers through newer demands set forth by the OEMs. Due to growing competition among OEMs and changing customer preferences, constant pressure exists among suppliers to keep prices as low as possible. Any reduction in scrap, rework, warranty claims, and recalls would have a positive impact on the overall cost savings.

Digitally-connected consumers can now make informed purchase decisions that will equip them with a robust bargaining tool. For instance, automotive consumers' ever-growing avidity for personalized vehicles is a major trend impacting the greater manufacturing industry. Besides, consumers demand faster deliveries that must be effectively managed by both the OEMs and the suppliers.

**Mass Customization Challenges**

As the industry moves into an era of configured mass customisation, manufacturers are expected to ensure reliability in product fit and finish, irrespective of different product configurations. Product components, modules, and sub-assemblies, therefore, need to be tested for quality in different combinations and configurations.

And the workforce needs to be equipped with all the necessary data that takes to create a top-class product. Aligning expectations and mass customization requests from multiple customers to the manufacturing process without confusing the internal team is a considerable challenge. Defects can creep in at any stage of manufacturing process and to prevent this manufacturers are required to define business standards and customer-specific requirements that can vary a lot in mass customization. Preventive quality management means regularly performing risk management and devising a quality plan at the early stages, e.g. applying the principles of failure mode and effect analysis (FMEA) to a control process change. This is difficult without a well-defined QMS in place. Despite the numerous benefits of mass customisation, it has always remained a challenge for OEMs and suppliers to achieve profitability at scale. Also, several departments and functions work independently within automotive manufacturing such as pressing plants, painting, powertrain, and assembly, each of which has its own set of quality standards. This means transparent and connected systems that can efficiently combine all of these quality standards to ensure traceability and a smooth, seamless flow of products from suppliers to OEMs to the end customer represent a major need in the quality management space.

**Global Initiatives Intensify Quality Compliance**

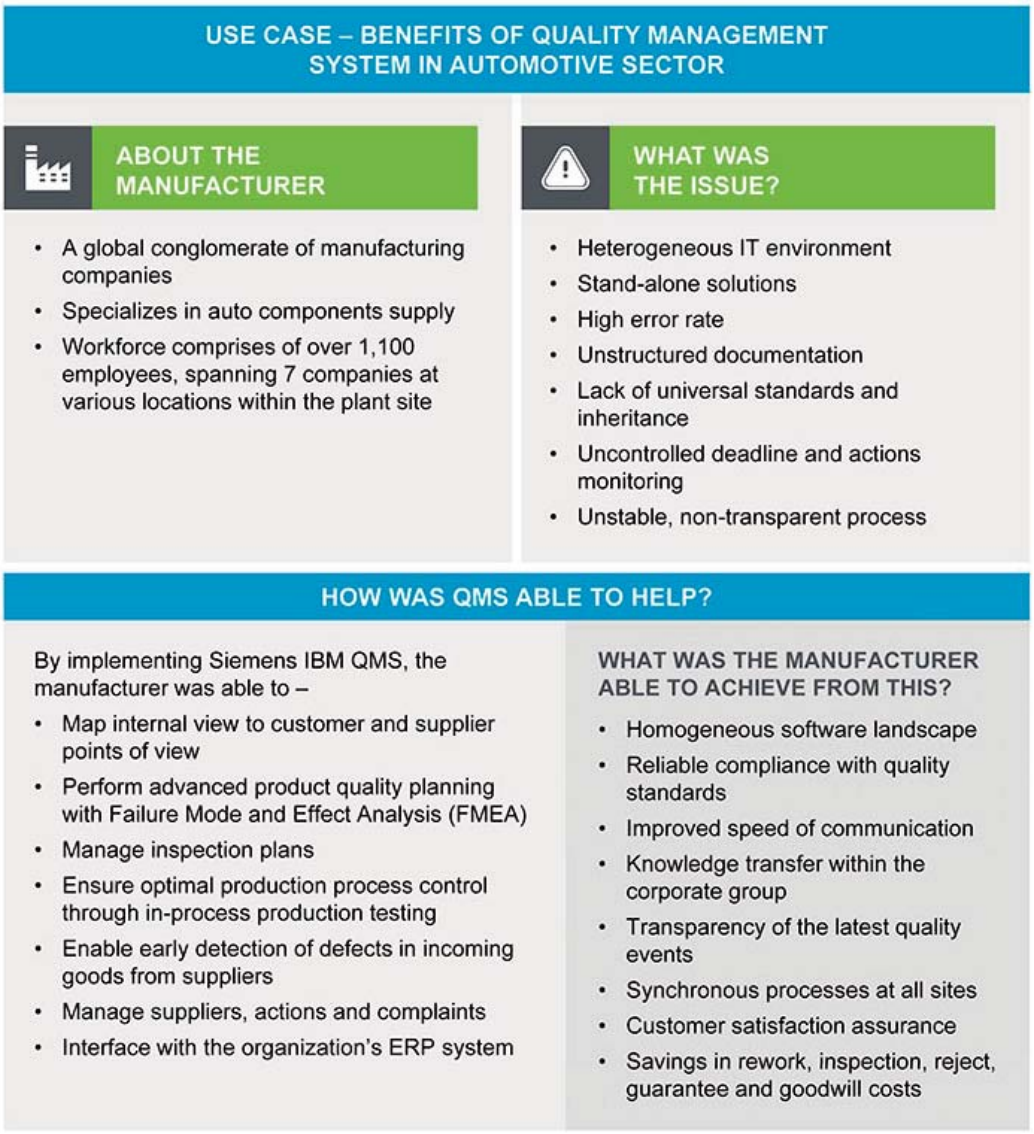
In comparison with other industries, the automotive industry has always been a forerunner in adopting advanced technologies within its realm of factory operations. It has also been in the vanguard of adopting quality standards and compliance measures for fairly complex requirements. Compliance to quality initiatives such as DIN EN ISO 9000, Q 101, IATF 16949:2016, VDA 6.1, and AIAG is important for automotive manufacturers. These standards help them continually improve their processes, avoid multiple certification audits, prevent defects, minimize variations, and ensure reduction of waste across the manufacturing value chain. And with the introduction of worldwide national initiatives such as the European Transport Safety Council (ETSC), the US NHTSA, and the Motor Vehicle Act, India, national governments are increasingly stressing importance of road safety measures.

These initiatives pressure OEMs and auto suppliers to ensure that the products they deliver comply with set quality standards to avoid legal hassles and tarnishing of brand image. OEM and supplier teams need to have access to inter-organisational knowledge, yet workforce migration could result in loss of information that is extremely crucial for the organisation. Accordingly, manufacturers are in need of a system that can track these changing standards, ensuring that there is no loss of information, and that all stakeholders have access to the latest industry information.

**Siloed Departments in Need of Unified Platform**

In most automotive organisations, quality control is handled within each distinct department. Different departments within the organisation have their own quality teams, which is why there is a need to integrate all functions into a singular unified quality system. Quality management in the automotive industry also requires visibility within plants and across multiple facilities located globally. The table in exhibit 11 exemplifies how an auto supplier conglomerate was facing issues with its disparate and heterogeneous IT environment before it implemented Siemens QMS IBS to integrate all of its stand-alone functions, thus saving unwanted costs arising from scrap, rework, and recalls.

**Exhibit 11: Use Case—Benefits of QMS for a large global conglomerate in the Automotive Sector**




*Source : Siemens*

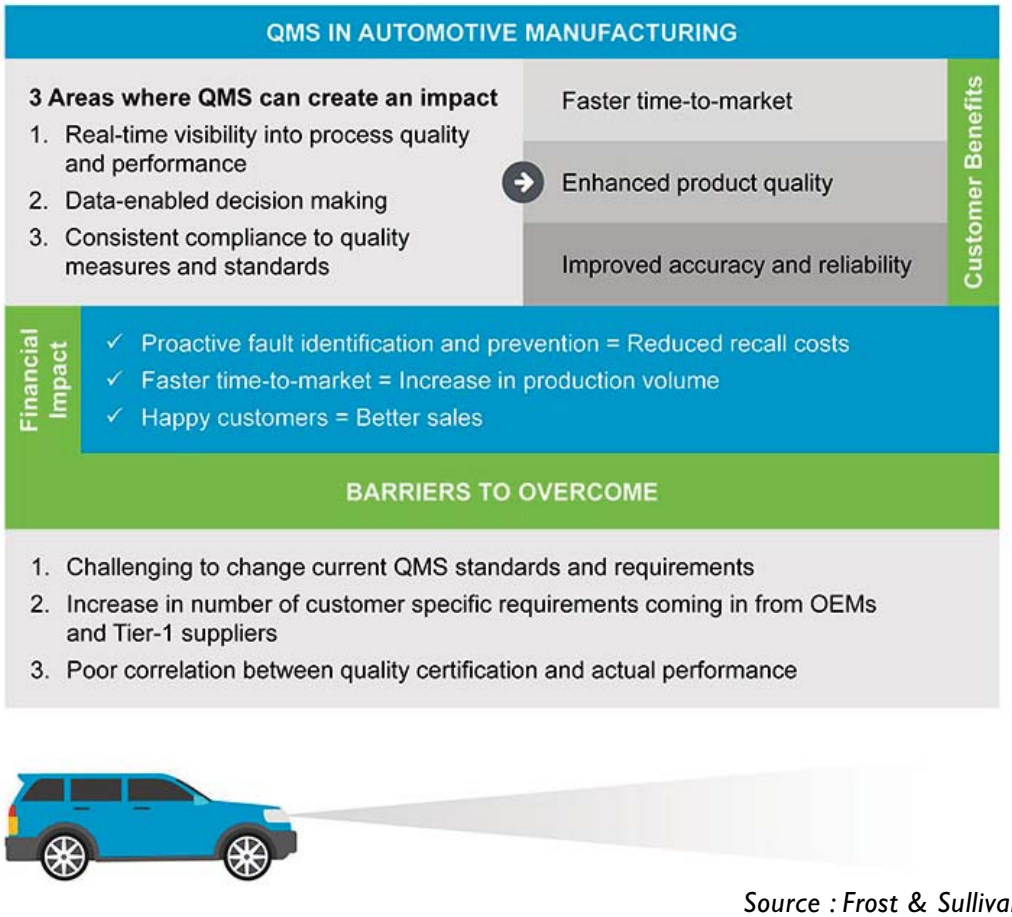
## Reconfiguring the OEM and Supplier Relationship

The dynamic OEM-supplier equation has undergone a drastic change over the years. What used to be one manufacturer juggling multiple suppliers is slowly changing into a single supplier supporting multiple manufacturers. It has, therefore, become necessary for OEMs and suppliers to work in closer collaboration.

The future of the auto industry rests on compliance to stringent quality standards.

One of the top reasons why QMS is important from an automotive standpoint is that it gives stakeholders (OEMs and suppliers) the ability to standardize business processes and systems. Multiple standards governing multiple systems, an overwhelming increase in customer requirements, and growing incidents of poor correlation between certification status and actual performance represent some of the chief concerns that are coercing auto suppliers to move toward adopting advanced QMS. In October 2017, Japan's Nissan Motor Co. had to recall more than 1.2 million[4] vehicles due to poor conformance to prescribed quality and safety standards. At a global level, such issues are even larger in intensity and volume. The following exhibit 12 indicates some of the key areas in automotive manufacturing where QMS can have an impact and few challenges that are still required to be overcome.

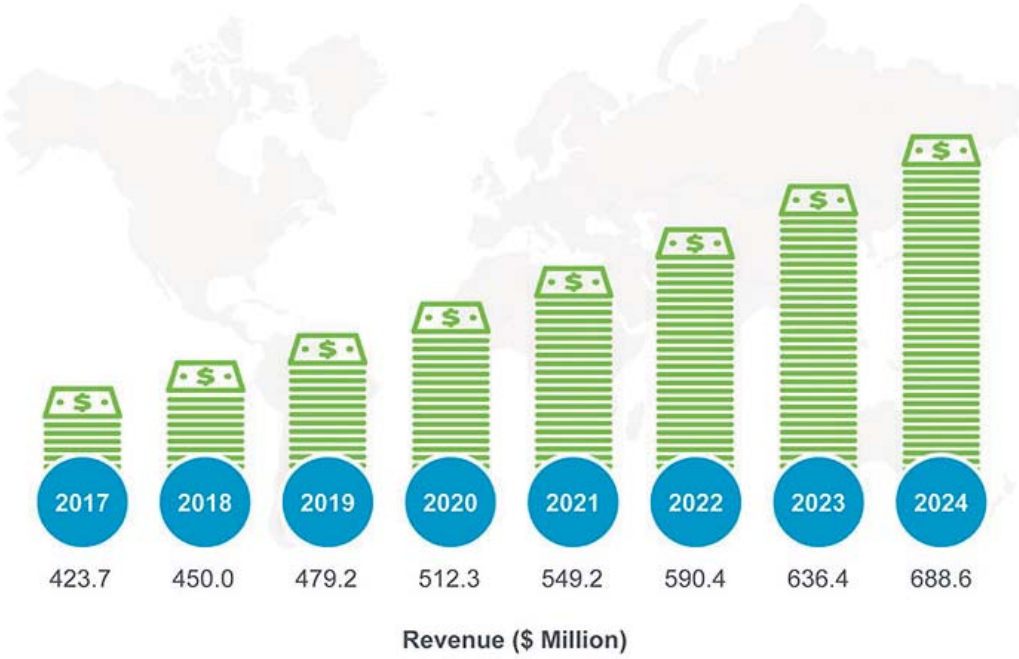
**Exhibit 12: QMS in Automotive Manufacturing**




*Source : Frost & Sullivan*

Apart from providing sufficient benefits to end-users of auto industry, QMS can also create a strong financial impact by reducing time to market and reducing recall costs as indicated in the exhibit above. Globally, the QMS market in the automotive sector is expected to grow at a CAGR of 7.2%. The following exhibit is an illustration of this growing trend.

**TOTAL AUTOMOTIVE QMS MARKET: REVENUE FORECAST, GLOBAL, 2017–2024 CAGR(2017-2024) = 7.2%**




*Source : Frost & Sullivan*

On an average, using QMS in automotive manufacturing can help manufacturers realize savings of 9%-10% of production cost per unit. The savings are realised primarily from reduction in product recalls, lower scrap production and higher operational efficiencies.

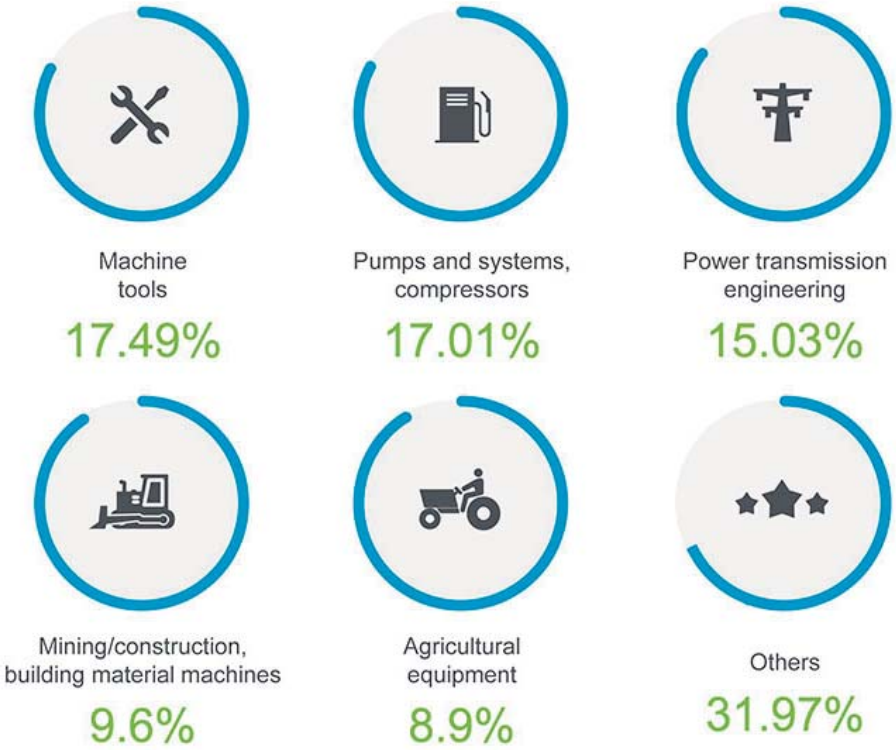
Cumulatively, this growing importance of quality in supplier networks, increasing standards and initiatives around quality, and the pressure to meet dynamic customer requirements will serve as a wake-up call for OEMs and suppliers—they need to make co-ordinated changes across all of their business functions to be truly successful at quality management.

A well-thought-out QMS will go a long way in helping both OEMs and suppliers overcome internal challenges and embark on a journey toward efficiently delivering high-quality products to their customers.

## QMS for the Industrial Machinery and Heavy Equipment Industry

The IM&E industry is one of the largest and most competitive sectors across the globe. It accounts for 15%6 of global manufactured goods, next only to other manufacturing verticals such as food and beverage, metals and mining, and chemicals. Among the wide range of machinery and equipment that is manufactured, machine tools; pumps, systems, and compressors; power transmission; construction; and agriculture equipment sectors lead the market in demand and size, as presented in exhibit 13.

**Exhibit 13: Industrial Machinery and Heavy Equipment Industry: Production Breakdown by Sector Global, 2017**




*Source : Statista, GTAI Research*

The IM&E industry involves a high degree of innovation and technology. During the production process, for instance, advanced technologies such as electronics, robotics, advanced materials, and software are used to deliver sophisticated technology to several other service and manufacturing industries such as mining and power transmission. Therefore, to cater to the technology demands of the IM&E industry, its component suppliers must meet advanced and high-precision standards to satisfy market requirements. To achieve these objectives, manufacturers must ensure quality at the supplier, as well as operator level, while mitigating rising competition, decreasing margins, and increasingly complex business requirements that keep them under constant pressure to deliver products with the highest accuracy compared to competitors and under fast time-to-market conditions. In this new climate, manufacturers find themselves in need of improved processes and systems that will help optimize their operations and ensure delivery of top-quality products. However, the challenges faced by these manufacturers are as diverse as their products. Some of the most frequently experienced quality issues in the key sectors of the IM&E industry are presented in exhibit 14.

**Exhibit 14: Frequently Reported Quality Issues in the Industrial Machinery and Heavy Equipment Industry by Sector**

| IM&E Sector | Manufactured Products | Frequently Reported Quality Issues |
|---|---|---|
| Machine tools | Metal cutting, metal forming, metal finishing | • Machine tool breakdown<br>• Electrical part breakdown<br>• Quality management after shipment<br>• Pre-emptive machine failure assessment |
| Pumps and systems, compressors | Positive displacement pumps & centrifugal pumps | • Suction piping incorrect<br>• Failure of machine components such as valves, compressor discs and diaphragms |
| Power transmission engineering | Gears, bearings, motors & drives | Wiring harness problems |
| Mining/construction, building material machines | Excavators, loaders, bulldozers, graders, trenchers & scrapers | Component failure:<br>• Wheels<br>• Drives<br>• Shaft & disks |
| Agricultural equipment | Tractors, soil cultivator, sorters, harvesters, planters, sprayers, loaders, conveyors & mowers | • Excessive or uneven tire wear<br>• Bulb failure<br>• Gearshift hard to operate<br>• Noisy brakes<br>• Excessive fuel consumption |

*Source : Frost & Sullivan*

These quality issues are critical for the IM&E industry and need to be constantly monitored at all times in order to be able to deliver products that are of high quality and conform to end-user requirements. Products manufactured by the IM&E industry must withstand harsh environments such as construction sites, oil refineries, and huge industrial plants; therefore, manufacturers are challenged to ensure that their products deliver uninterrupted uptime during operation. Any disruption in normal workflow could result in monetary and reputation losses. This means that manufacturers need to get their products right the very first time.

*Use Case: John Deere recalls 25,000 lawn tractors due to crash hazard*
*In September 2017, John Deere announced a recall alert of 25,000 lawn tractors and related service parts due to transmission issue that can lead to a crash. Consumers were instructed to immediately stop using the recalled lawn tractors and contact John Deere for a free repair. The company suffered monetary losses over these quality issues, followed by a dip in stock prices as Deere's stock slipped a little over 1.7% over the past three months.*

**Need for Improved Networks**

Most products manufactured in the IM&E industry are distributed via supply chains spread across the globe. Every manufacturer wants to source the best and most cost-effective components from top suppliers stemming from different parts of the world, so it is extremely important that the suppliers are reliable and that the components purchased from them consistently meet the prescribed quality standards. But as product requirements and supply chains become increasingly complex, the deep-rooted risks grow in intensity. Not only can quality failures be cataclysmic to the principal brand, serious repercussions can also be felt throughout the value chain. This, in turn, amplifies the need to build a strong and connected supplier-manufacturer-operator network.

Ensuring conformity to product and process quality standards can get extremely demanding when involving suppliers each working with disparate IT systems, different production schedules, and dissimilar design and process metrics. In other words, unpredictable and unreliable process data and quality records from hundreds of suppliers stored in different formats restrict the manufacturer from making business-critical decisions. For instance, supplier corrective action reports (CARs) and preventive action reports (PARs) created in response to quality issues are frequently lost in the labyrinth of supply chain and IT systems, resulting in static processes with unrealized capabilities for continuous improvement.

IM&E manufacturers are challenged to offer customized products that meet individual customer needs. The average lifetime of industrial machinery and heavy equipment is typically 10 to 19 years. During this tenure, it would be challenging to maintain and trace out relevant details from the physical records of such equipment. Moreover, with global operations, these manufacturers sell their machines and equipment to multiple locations all around the world. Yet the service network is complex, and servicing a global customer that is dealing with a malfunction proves challenging. Downtime can excessively affect businesses and create a long-lasting negative image of the brand, so anything less than immediate service can blur the probability for a repeat sale. The IM&E industry typically takes about 3 days to address a machine maintenance or quality issue. This loss of time can significantly impact productivity and revenue. Accordingly, it is imperative for these manufacturers to utilise a connected quality management system that can help connect manufacturers with their service contractors and customers to effectively and efficiently trace products back to their origin.

**Challenges: Government Regulations, Siloed Departments, and Disparate Data Formats**

The manufacturing of industrial machinery and heavy equipment is monitored by rigid government regulations with respect to safety and sustainability, documentation of errors on the production line, increased product liability requirements, and tighter plant safety regulations.

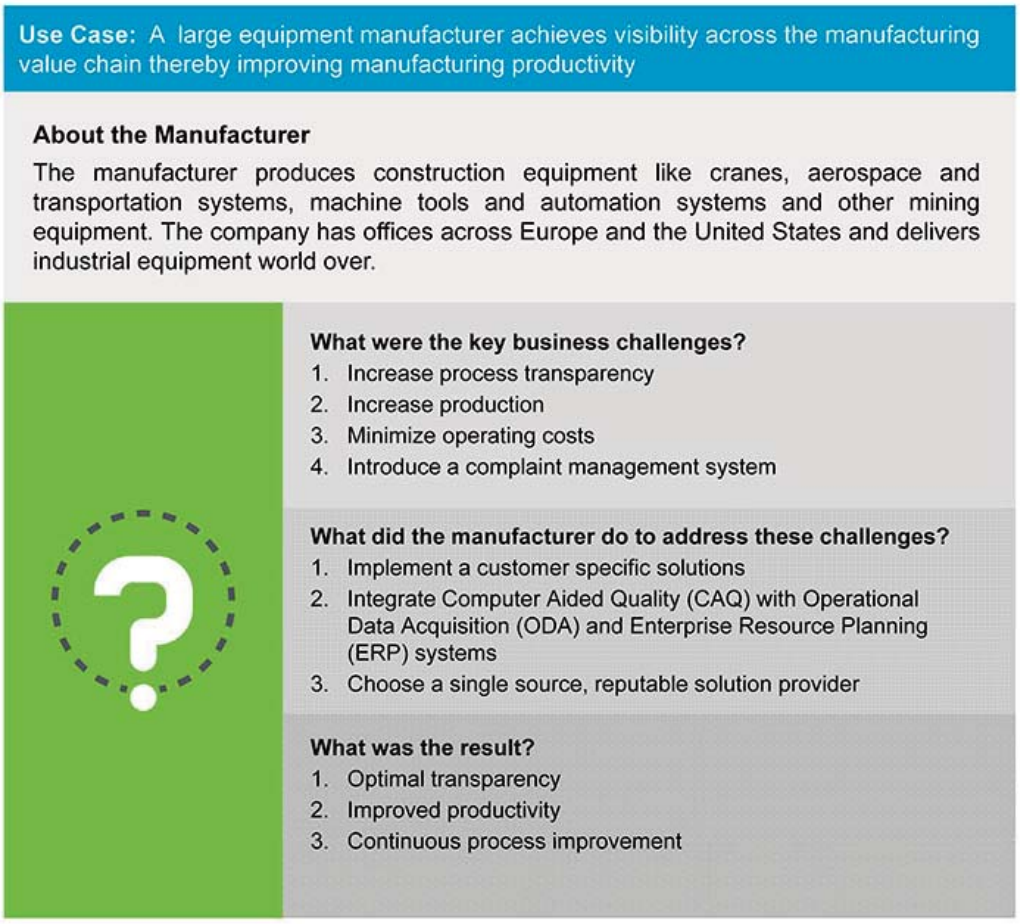
In addition, customers in the agricultural, construction, and mining industries demand innovations to meet emissions regulations and to improve work-site efficiency and performance. In light of the regulations and industry standards, every machine must be configured to unique specifications. In response, manufacturers depend upon a centralised system that will keep a record of the latest industry standards and government regulations and effectively communicate among the different departments in the organisation.

Moreover, in the IM&E industry, design, engineering, and manufacturing departments often operate in siloes, which ultimately leads to unnecessarily high costs and slow time-to-market. The problem is threefold. First, IM&E manufacturers need to ensure that their manufacturing processes are integrated with advanced technology to improve employee productivity. Second, there is a need for greater dexterity into business planning, design, and production to manufacture sturdy and efficient IM&E equipment, yet several teams located in multiple locations across the world are required to work on the same set of data. Third, IM&E manufacturers face the need to communicate and maintain a record of quality issues that happen on the shop floor as and when they occur in support of Corrective and Preventive Action (CAPA).

Quality management is increasingly being driven by OEMs with the buying power that will enable their suppliers to make changes to the QMS software they use. By pushing quality standardization and improvements across the manufacturing value chain, the industry can help ensure agility and improved productivity. If the OEMs and the suppliers are on the same technological level and have employed the same QMS software, OEMs will create transparency and be able to communicate more sophisticated information with their suppliers and vice versa. Currently, however, data is provided in a myriad of formats and has to be corrected or modified to match a particular format and then entered.

The following exhibit 15 illustrates a typical case example of how a large equipment manufacturer was able to achieve visibility across the manufacturing value chain using a well-designed QMS.

**Exhibit 15: Manufacturing Value Chain Visibility - Use Case**




*Source : Siemens*

## The Need

Cumulatively, the manufacturing value chain challenges and quality issues represent the growing demand for a software solution that is able to centrally address the complex needs of the supplier-OEM network and manage all the data it generates. Suppliers, in particular, need this software because they are continually evaluated by OEMs on three major issues when providing a product, namely quality, productivity, and delivery.

Suppliers looking to prove their ability to consistently sustain these factors at a high level must achieve the following activities:

a) Maintain operations under a strong quality system encompassing all industry demands

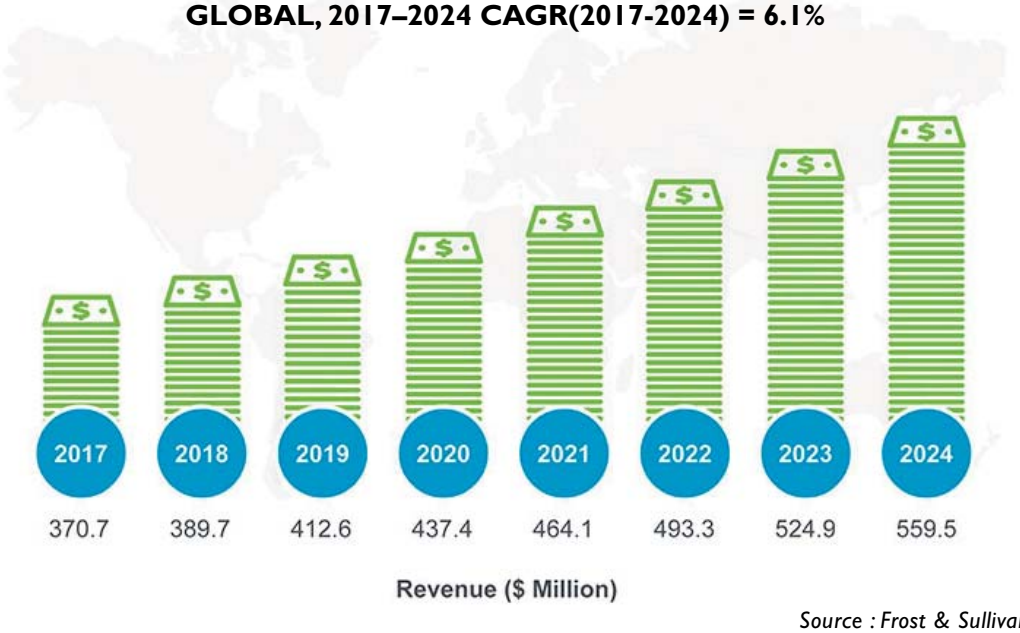
b) Provide complete documentation of standard operating procedures (SOPs) in which employees are trained

c) Make sure all systems are validated

d) Have quality systems in place for Complaint Handling, Non-conformance, Root Cause Analysis, and CAPAs

These factors—quality, productivity, and delivery—indicate the importance and criticality of on-time provision of maintenance and repair services by the IM&E manufacturers. Doing so will help these manufacturers increase cash flow, satisfy employees, enjoy repeat customers, and open windows to newer opportunities. The market for QMS in IM&E is expected to grow at a CAGR of 6.1%, relatively lower when compared to the automotive sector. The market is expected to reach $559.5 mn by 2024. The following exhibit is an illustration of this growing trend.

**TOTAL IM&E QMS MARKET: REVENUE FORECAST, GLOBAL, 2017–2024 CAGR(2017-2024) = 6.1%**




*Source : Frost & Sullivan*

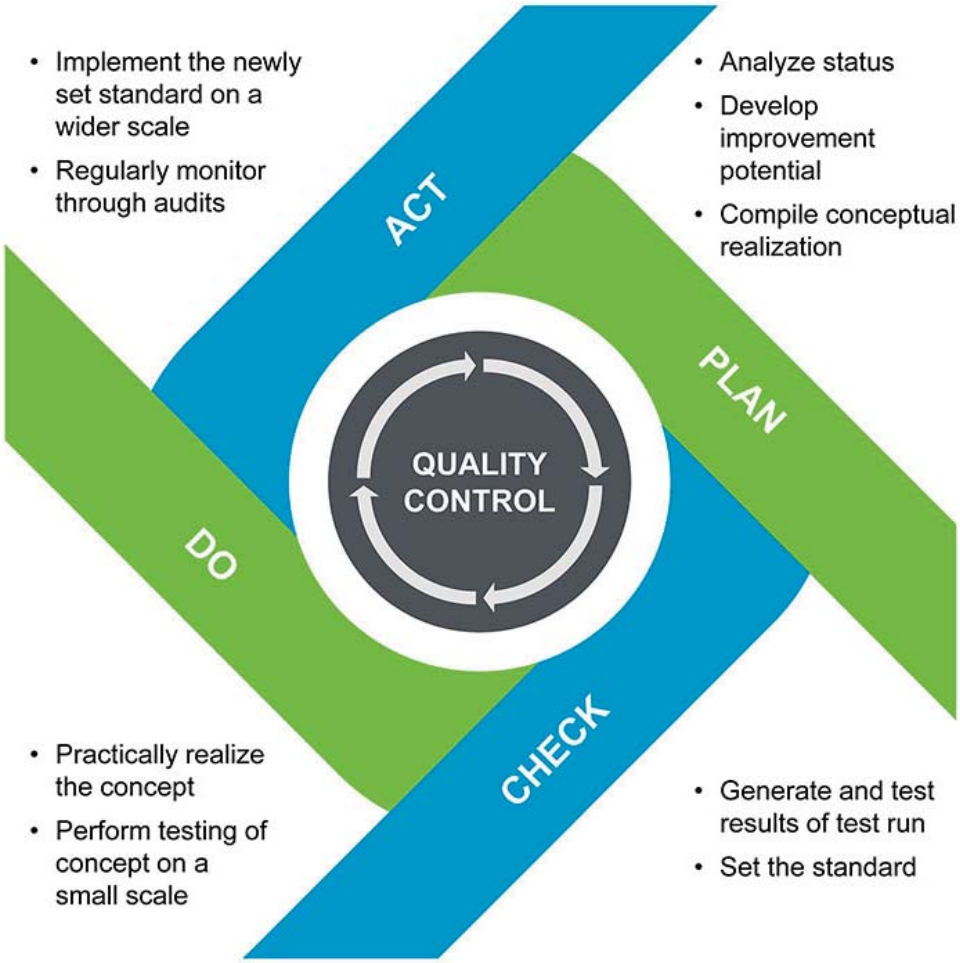
Utilising QMS in IM&E industries can enable manufacturers reduce overall cost of production between 11%-13% on an average. In essence, it is important that IM&E manufacturers fully tap the potential of single-source, reputable QMS software to ensure high customer loyalty in the face of competition and the need for differentiation.

**The Siemens Approach**

As demonstrated in previous sections of this paper, an increasing number of quality-related issues in manufacturing are driving the market for QMS software. Siemens PLM Software has been rapidly advancing in this area with delivery of its popular cross-industry and closed-loop quality management software. Named Siemens IBS QMS, this software from Siemens PLM has a rich history of over 30 years in providing quality management solutions to industries. The software is based on the Plan-Do-Check-Act (PDCA) cycle and is designed to ensure continuous product lifecycle and supply chain improvement by managing complexities involved in planning, controlling, and monitoring processes and corporate quality. The PDCA cycle in quality management elucidates the different phases of continuous improvement in the PLM and forms the crux of all quality management systems. The following Exhibit 16 is an illustration of how the PDCA cycle forms an integral component of product lifecycle and quality management.

One of the topmost reasons behind manufacturers using the Siemens IBS QMS is the flexibility and ability to seamlessly integrate with existing Manufacturing Operations Management (MOM) and PLM systems. Siemens' PLM and MOM systems are already proven and widely used solutions in the industry. Ideally, quality planning must begin right from engineering and designing a product and should be a required element during the entire manufacturing process. Siemens IBS QMS fulfils this criterion. The software also has the ability to integrate the management of Bills of Materials (BOM) and Bills of Process (BOP) and sharing these engineering objects across Siemens Teamcenter with all other Siemens MOM portfolio elements to enable risk management. Designed as a multi-lingual, multi-plant and cross-industry QMS solution, Siemens PLM Software follows industry-specific quality standards and helps manufacturers across sectors mitigate risks and potential failures before they occur.

**Exhibit 16: The Plan-Do-Check-Act Cycle**




*Source : Frost & Sullivan*

The quality data gathered continuously during the design and production processes helps initiate problem solving through continuous learning and is crucial for continuous improvement of product and process. Using Siemens IBS QMS means organisations are also able to manage global operations across various disciplines and build products faster, more efficiently, and with greater flexibility. Further the ability of the software to be integrated with other Siemens PLM and MOM modules help provide the industry with a solution that is not just restricted to the management of quality alone but instead is more holistic and complete in nature.

Industries such as automotive and IM&E manufacturing are characterized by challenges such as shorter development times, and increasing number of product segments. These challenges along with manufacturing objectives such as optimal processing times and reduced failure costs can be better achieved with the support of innovative and advanced IT technologies from experienced QMS software providers such as Siemens. With the help of Siemens IBS QMS, companies can begin quality planning as early as in the design and engineering phases and can further optimize and control quality continuously during the manufacturing process.

The PDCA cycle with its four phases of continuous improvement process is the basis for Siemens quality philosophy. Siemens IBS QMS further comes with several additional modules such as APQP/Project Management, Failure Modes & Effects Analysis (FMEA), Gage Management, Control Plan, Process Flow Chart, Inspection Planning, Quality Action Management (QAM), Warranty Management, Audit Management, Incoming/Outgoing Goods Inspection, Statistical Process Control, Concern and Complaint Management, Supplier Management, Inspection Reports, and Product Part Approval Process (PPAP).

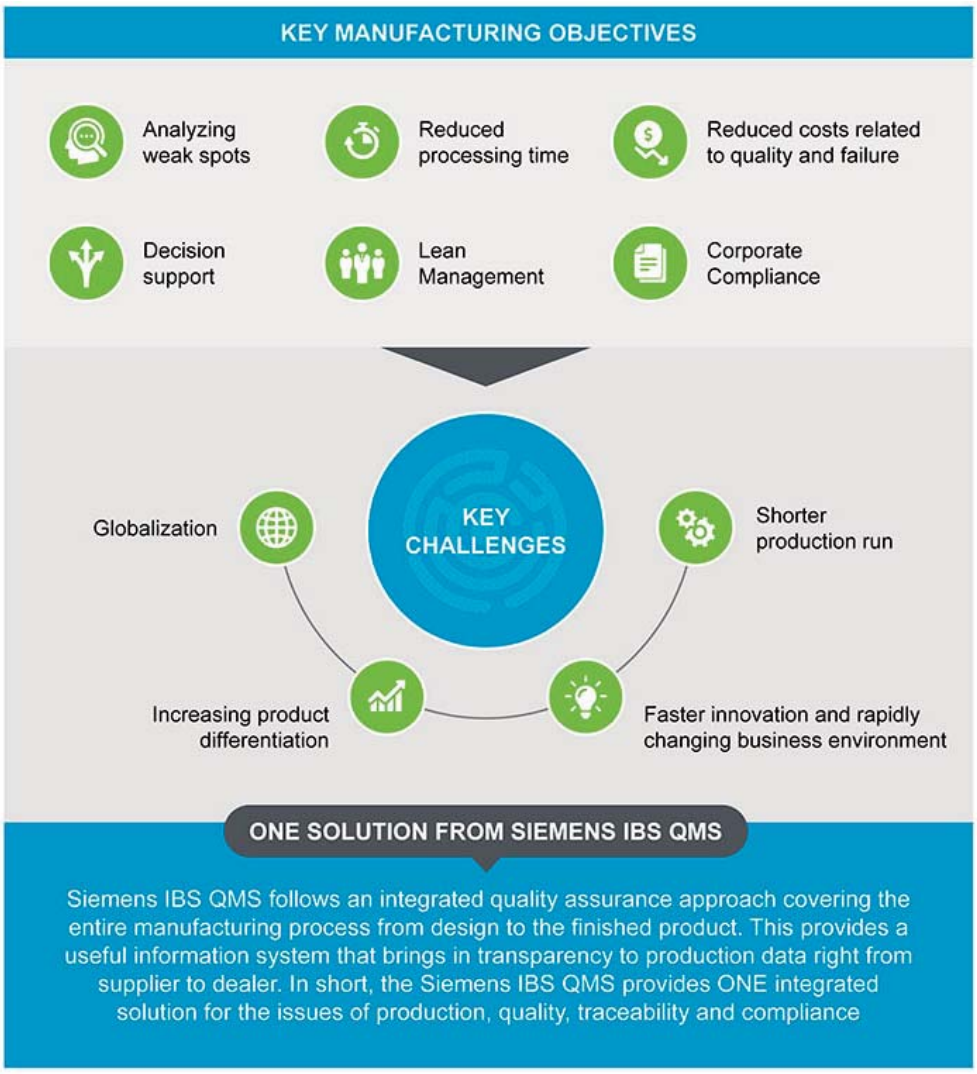
With the help of these modules, manufacturers get end-to-end visibility into their operations and related issues. These modules help organisations oversee quality management across various manufacturing stages, such as the following:

a) Research and development, construction, and work scheduling

b) Raw materials procurement, manufacturing, and assembly

c) Final product inspection, sales, and service

**Exhibit 17: Siemens IBS QMS: One-stop solution for all manufacturing needs**




*Source : Siemens*

The following example illustrates how these advanced QMS capabilities can help organisations overcome potential failures caused by poor quality.

**Exhibit 17: A leading global manufacturer of installation technology employs Siemens IBS QMS in reducing buffers achieved subsequently from improved confidence in raw material quality**


*Source : Siemens*

Implementing an integrated quality management approach remains the topmost concern for most manufacturing organisations. As more and more organisations realize the importance of integrated QMS software, their concern intensifies about how to fully tap the return on investment (ROI) from these implementations. Yet the payback is clear when considering that these solutions support the entire product and process lifecycle and aid in replacing the current heterogeneous OT landscape with a single platform.

A centralised approach to quality management is, without a doubt, becoming increasingly critical as the OEM–supplier equation is rapidly transforming. Siemens' holistic, end-to-end approach to quality management through its in-depth understanding of the industrial environment can go far in helping organisations realize the extent of quality implications and derive benefits that will improve overall operational efficiency and result in the ROI they desire.

## Conclusion

The utility of quality management software has been growing steadily over the years. Its significance is only poised to become even stronger with emerging trends of digitalisation, customer personalisation and increased competition. Currently, more stringent government regulations and an increase in quality-related issues have given rise to product recalls and production downtime, a clearly indication of the need for efficient quality management systems. The advent of digitalisation initiatives (like Industrial IoT, Industry 4.0) is expected to further increase production complexities, necessitating a more integrated and holistic approach towards quality management.

QMS that offers end-to-end integration of a manufacturer's value chain is integral to a manufacturer's business goals, providing complete visibility, traceability, and service information—from product design to maintenance delivery. This quality management information is crucial to ensure optimal product engineering, resulting in superior customer delight. This white paper has outlined the evolution of customer requirements and business needs as well as uncovered the impending quality issues and challenges that threaten the automotive and industrial machinery and heavy equipment sectors. The paper also discussed the importance of QMS and offered examples of how manufacturing challenges can be overcome by adopting QMS in a holistic approach along with PLM. To illustrate this point, we highlighted the Siemens QMS approach that is designed as part of the company's larger PLM strategy.

The benefits of such an approach includes decreased time to market, real-time evaluation of quality issues and product failures, prevention of product recalls (that could tarnish brand image), and continuous quality improvement processes that can help decrease waste generated and lower product costs. With manufacturers beginning to comprehend the huge impact of poor quality, there is a newfound realisation that quality is a shared responsibility across the value chain and not an exclusive responsibility restricted to a given division within an organisation. In a global manufacturing ecosystem creating top-down visibility into quality management can be a daunting challenge, yet this is where a holistic solution, like the one proposed by Siemens, can benefit and add immense value.

Reference Links:

1) http://wdi.worldbank.org/table/4.2

2) http://www.toyota-global.com/

3) https://www.usafleetsolutions.com/nhtsa-reports-53-2-million-auto-recalls-in-2016/

4) https://www.cnbc.com/2017/10/02/nissan-to-recall-1-point-21-million-vehicles-in-japan-after-faulty-checks.html

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