BENEFITS OF APPLYING QUALITY MANAGEMENT TECHNIQUES TO SUPPORT SUPPLY CHAIN MANAGEMENT

José Carreño Ramos¹, Şeyda Serdar Asan², Jasmin Majetic³

Abstract — As the customer demands change, businesses grow, technology evolves, and the competition gets more intense companies realize the importance of managing their supply chains. Quality management (QM) is a well-accepted system of management that aims at long term success through continuous improvement, which is supported by various quality techniques. This paper addresses that blending QM and SCM would result in higher benefits than their sole application. Until now, research has mainly studied the critical QM factors and their effects on supply chain processes and supply chain performance. However, there is little evidence that addresses the benefits of applying QM techniques to support SCM activities. This paper tries to shed some light on this issue with the help of three case studies taken from industry and aims to explore how QM techniques support and improve SCM activities throughout the supply chain.

Keywords — quality management, quality management techniques, supply chain management, supply chain quality management

INTRODUCTION

Globalization forced companies to expand their businesses to new geographies where availability of raw material, access to trained people, and new markets, among others, can offer them competitive advantages. These changes, in turn, lead companies to transfer their business processes to different suppliers and partners, relying on their capability to produce and deliver high-quality products and making them responsible for an important part of the final product. Maintaining the performance of the whole supply chain at a high level requires integration, cooperation, communication, participation, and sharing of information between supply chain partners. One of the means of achieving this objective is to apply Quality Management (QM) techniques to support the supply chain activities. Since the ultimate objective of both QM and Supply Chain Management (SCM) is continuous improvement and customer satisfaction, it makes sense to join their forces in order to improve the performance of the whole supply chain.

There is extensive number of studies both on QM and SCM in the literature, yet the studies examining them jointly are relatively limited in number. These prior studies examine mainly the application of QM in the supply chain environment, and its impact on performances and only a few of them consider the SCM concept. Recent efforts to blend QM and SCM produced the term supply chain quality management. However, there is still little evidence reported on the benefits gained in SCM activities through applying QM in practice.

This paper aims to present how QM techniques are applied to support SCM and the benefits gained from these efforts. With this aim in view, the paper first briefly addresses SCM and QM and their intersecting points. It then discusses the benefits of supply chain quality management. In addition, with the help of three case studies from different supply chains the benefits gained regarding SCM by applying QM techniques in supply chain are demonstrated. Finally, the evidence gathered from the case studies is discussed and future research directions are mentioned.

SUPPLY CHAIN MANAGEMENT

According to [1], a supply chain “consists of all parties involved, directly or indirectly, in fulfilling a customer request.” It is a complex network of business entities (e.g. suppliers, manufacturers, distributors, service providers, warehouses, customers) involved in the upstream and downstream flows of products/services, finances and information (Figure 1) [1-3].

One of the aims of a supply chain is to satisfy customer requirements which, in turn, would lead to improved performance of the individual companies as well as the whole supply chain. This can be achieved by treating the downstream party as a customer, an approach which was first introduced in total quality management. A customer would be satisfied as long as the supplier ensures high quality, flexibility and faster

¹José Carreño Ramos, Technical University of Berlin, Quality Sciences Department, jcarpkba@mailbox.tu-berlin.de
²Şeyda Serdar Asan, Technical University of Berlin, Quality Sciences Department, serdars@itu.edu.tr
³Jasmin Majetic, Technical University of Berlin, Quality Sciences Department, majetic@qw.iwf.tu-berlin.de

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November 8-9, 2007, Istanbul, TURKIYE
response to demand. This is valid for all parties in the supply chain, all of which are indeed in a customer-supplier relationship. If we define success as satisfied customers, then the success of a supply chain depends on the success of each and every company in it. The key activities that are required to achieve a successful supply chain are integration, cooperation, long-term focus on partnerships, sharing information, extensive communication between supply chain parties, sharing of risks, rewards and goals [3]. These key activities are involved in SCM, which is defined as “the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long term performance of the individual companies and the supply chain as a whole” [3]. The underlying idea of the SCM is the integration of business processes throughout the supply chain, for which the prerequisites (i.e. coordination, information sharing, visibility, and synchronization) should be achieved [4]. When parties in the supply chain are integrated, they can collaboratively identify the critical success factors to act on, decide on the improvement and innovation areas in the business processes, negotiate on the standards, and in turn improve their performance levels and meet customer requirements.

![SCM Diagram](image-url)

**FIGURE 1**
Material, information, and financial flows in a supply chain, adapted from [3]

## QUALITY MANAGEMENT

According to the International Standard ISO 9000:2000, quality is defined as “degree to which a set of inherent characteristics fulfils requirements”. Here “inherent” – as opposed to assign – means existing in something, especially as permanent characteristics. The “requirements” in the quality definition addresses three elements: quality requirements for systems, quality requirements for processes (aiming high process capability) and the quality requirements for products (specifications deduced from customer expectations, technical specifications, product standards, regulatory requirements) [5]. Consequently, QM is understood as: “coordinated activities to direct and control an organization with regard to quality” [6]. It is important to know that direction and control with regard to quality, generally includes establishment of the quality policy, quality objectives, quality planning, quality control, quality assurance, and quality improvement. (See Table 1)

The part of an organization’s management system that focuses on the achievement of results in relation to the quality objectives and to satisfy the needs, expectations and requirement of the parties is the Quality Management System (QMS). It is defined as the “management system to direct and control an organization with regard to quality” [6]. In order to assure an efficient and effective QMS, the ISO 9000 suggests adoption of eight QM principles [6]. Definition of each principle [6] and the main benefits of their adoption in a supply chain system are listed below.

1. **Customer focus**: Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations. Main benefits include systematically managing customer relationships, and ensuring a balanced connection between customers and other parties.

2. **Leadership**: Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization’s objectives. Main benefits include considering the needs of all parties as a whole, develop better communications, creating and sustaining shared values, and establishing trust.
TABLE 1
Quality Management Activities [13]

<table>
<thead>
<tr>
<th>Products</th>
<th>Processes</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish and announce quality policy</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Determine responsibility for quality</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Determine quality related cost objectives</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

- Determine quality characteristics
- Establish inspection and testing plans
- Set up plans for quality management

<table>
<thead>
<tr>
<th>Quality control</th>
<th>Products</th>
<th>Processes</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide quality techniques</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Prepare and carry out quality related training</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Draw up quality reports</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Carry out audits</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Control testing and inspection equipment</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Laboratory inspection</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Control purchased and produced parts</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

- Organize, establish, maintain product related documentation
- Organize, establish, maintain process related documentation
- Develop, establish and maintain quality handbook

<table>
<thead>
<tr>
<th>Quality improvement</th>
<th>Products</th>
<th>Processes</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan improvement programs</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Draw up review on improvements</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

3. Involvement of people: People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization’s benefit. Main benefit is high motivation of the employees to participate in and contribute to continuous improvement.

4. Process approach: A desired result is achieved more efficiently when activities and related resources are managed as a process. Main benefits include lower costs and shorter lead times, improved and better predictable results, establishing clear responsibilities, and evaluating risks and consequences of activities on customers, suppliers and other interested parties.

5. System approach to management: Identifying, understanding and managing interrelated processes as a system contributes to the organization’s effectiveness and efficiency in achieving its objectives. Main benefits include ability to focus effort in the key processes, understanding the interdependencies between the processes of the system, structured approach to synchronize and integrate processes, and reduce cross-functional barriers.

6. Continual improvement: Continual improvement of the organization’s overall performance should be a permanent objective of the organization. Main benefits include flexibility and alignment of improvement activities at all levels and parties.

7. Factual approach to decision making: Effective decisions are based on the analysis of data and information. Main benefit is structured and robust decision making systems.

8. Mutually beneficial supplier relationships: An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value. Main benefits include establishing long term relationships, sharing information, cooperation with suppliers in order to identify and satisfy the requirements. This principle involves working with suppliers even at early stages of the process (e.g. design) as well as to reduce the number of suppliers and work with those who are capable to fulfill the quality requirements [7-12].

SUPPLY CHAIN QUALITY MANAGEMENT

QM has a widespread industrial adoption and is indeed executed in every supply chain, due to the fact that every company is a part of at least one supply chain. There are several benefits that can be gained by applying QM in the supply chain. For example, applying QM at each stage throughout the supply chain would be reflected in the final product [10, 14], and would result in improvement in employee and customer satisfaction as well as improvement in performance of supply chain parties [15]. Thus, there are several studies considering some aspect of QM within a supply chain perspective; however involvement of QM practices in the management of the supply chain is less prevalent in the literature (see [16-26] among others). From the review of SCM and QM, we can list the issues shared and encouraged in both approaches as systemic...
Recent efforts to blend QM with SCM introduced the term Supply Chain Quality Management (SCQM) [20-22]. SCQM is the coordination and integration of supply chain business processes to measure, analyze and continually improve products, services, and processes with the purposes of creating value and achieving satisfaction of intermediate and ultimate customers in the business and market [22].

There are several reasons to consider the application of SCQM. First of all, the days when QM was applied only inside the walls of a single firm are over. Since the ultimate goal is to satisfy and fulfill the needs of all customers, QM practices must spread throughout the supply chain to include suppliers, customers, manufacturers, service providers, distributors, and the teams within these organizations. Second, QM can be applied in any organization and structure, thus its application to supply chain business processes is promising to jointly achieve common goals. Moreover, issues such as involvement of suppliers and customers in the early stages of the product development process [7-9] and cooperation with suppliers and customers [6, 11] in order to understand and satisfy customer requirements are promoted in both QM and SCM.

As a final point, the application of SCQM would result in customer satisfaction, continuous improvement, high commitment and motivation of all the parties involved. The prerequisites as well as the benefits of applying QM and SCM jointly seem to be clear; but when we consider its application in real life the results are somehow unclear and difficult to figure out [9, 25]. Therefore the gap to be covered is the presentation of real examples, to reveal how the implementation of QM has helped to support and improve SCM activities. This paper tries to fulfill this gap by presenting three case studies.

**SUPPORTING SCM ACTIVITIES BY QM TECHNIQUES**

The integration of QM and SCM requires the alignment of focus between the organizations in the supply chain. Alignment can be achieved by adopting a common understanding which is shared by all members, at all stages and levels of the supply chain. This paper suggests that such common understanding can be achieved through the application of the QM techniques.

It has been presented in several studies, that the application of QM techniques has been successful in different industries. Companies like AT&T, 3M, Hitachi, Sony, Johnson & Johnson [24], Motorola, General Electric, Rolls-Royce, MCC, among others, have used the quality techniques to improve their processes. In industry, it has also been observed that companies are committed to support their processes by implementing techniques to ease the work of the employees, to solve systematically problems, and to document processes. Such evidence indicates that the implementation of techniques already proved in those companies with satisfactory results is a good point to start the task of alignment of focus in a supply chain.

By means of three case studies, this paper aims to present how top-level companies implement QM techniques to improve their SCM activities and the benefits gained. Of the three cases presented in this paper the first two are based on data gathered from secondary research, and the last one was observed directly by one of the authors. Before presenting the cases, for a deeper understanding, its better to mention the two techniques (i.e. Failure Mode and Effect Analysis and Statistical Process Control) that were applied in the three case studies.
Failure Mode and Effect Analysis (FMEA)

FMEA “is a systematic team-oriented approach in order to identify and to evaluate potential failure causes, failure modes and failure effects before their occurrence, and to determine actions for their prevention” [13]. Its main objectives are to identify in early stages of the process potential failures (prevent), determine the effect they can have on the product or process, and take the necessary actions to avoid or diminish their occurrence [27]. Application of the technique can be described in five steps [13]:

1. Identify the system elements of the product and system structure including all its components,
2. Develop a function structure for the system elements, i.e., describe their utility within the system,
3. Develop a failure structure of each element in the system (what are the reasons or causes of the failure),
4. To prioritize the most critical failures, calculate the risk priority index with the formula: 
   \[ RPI = O \times S \times D, \]
   where \( O \) is occurrence is the probability of an error to happen, \( S \) is severity is the impact of the failure when it reaches the customer, and \( D \) is detectability is the probability to discover the error before it reaches the customer.
5. Take actions to reduce the likelihood of failures occurrence and to improve controls for detecting them.

Statistical Process Control (SPC)

SPC refers to the use of statistical techniques (e.g. control charts) to analyze, monitor and control the variation of the process variables (determined characteristic on raw materials, machines, etc.), with the aim of carrying out necessary actions to control and minimize the defects [8, 28]. Scatter diagrams, Pareto charts, Cause-and-Effect diagrams and Control Charts are examples of tools used for SPC to monitor and control quality [8]. As a result of its application, the following benefits can be achieved [28]:

- Provides feedback about process characteristics, variables and performance.
- Detect chance and assignable causes that affect process performance.
- Understand the interaction among process variables which results on performance improvement.
- Minimizing the cost of quality.

The Motorola Case

Motorola defines its quality system as a group of activities and events specially designed to ensure that any deliverable product, service or process will fulfill the expectations of the customer [29]. To achieve this purpose, the company included in their daily activities internal and external supplier control as well as problem-solving techniques. The Motorola Case, based on [29], describes how the implementation of the SPC helped to improve the performance of Motorola and its suppliers.

From the tools used in Motorola, SPC was one of the first applied, specifically in the Austin Assembly facility. Training was carried out at the beginning through participation of an external consultant and an in-house coordinator whose task in the near future would be to maintain and transmit the lessons learned for further development and implementation. Management defined target numbers to be achieved through SPC and asked for preliminary reports about the status of the SPC implementation in a determined point of time in order to track the implementation process and the training effectiveness. The essential elements of SPC were defined as: (1) problem-solving team integration, (2) training programs, (3) improvement in employee attitude, (4) improvement in communication among employees and between management and employees, (5) a quality certification program and (6) design of experiments. With an optimal execution of these six elements, the SPC implementation would bring positive results. Each team was supported by an upper level manager (sponsor) whose task was to keep the team in the same track and provide it of resources.

The next step was to select coordinators for each team who already had some statistical and problem-solving techniques background. They were responsible to teach other techniques and to attend meetings with other areas, in which the status of their own teams were shared and presented.

The SPC training was implemented at all levels of the organization, based on the responsibilities and activities of each employee (work-oriented training); e.g., operators and inspectors were trained on how to collect data, on the creation and understanding of control charts, and to participate in problem solving groups; an advanced training in statistics as well as design of experiments were introduced to engineers and technologists: they were trained in how and when to use control charts to monitor a process, to identify possible trends, causes and solutions, as well as to document them. The emphasis shifted from a try-and-error basis to a statistical focus and from an individual approach to a cross-functional collaboration to solve problems in which different areas were involved. [29]
From the SCM perspective, first of all, cross-functional collaboration was encouraged. Motorola certified most of its suppliers and in turn avoided the incoming inspection procedure and reduced the rate of rejected parts. Using SPC they evaluated process capability of the suppliers. Suppliers that were able to deliver a high-quality product were considered as part of the suppliers’ base which lead to reduction in the number of suppliers.

The MCC Smartville Case

The particular assembly plant of the Smart car of Micro Compact Car AG (MCC) – a subsidiary daughter of Daimler Chrysler in Hambach, France – is an interesting example of supplier integration and collaboration. The uniqueness of the structure is not only the fact that all suppliers, which are recognized as partners, are sharing a common area, but the active participation in the manufacturing process of all the parties involved [30]. Each component used for the assembly of the cars is outsourced from eight different suppliers, which are producing components exclusively for MCC [30]. There are a total of 15 suppliers providing different services (including information technology and logistics) and accounting for the 88% of all value added activities during the production and delivery of a Smart car [31]. Each partner produces a certain component or module in Hambach and delivers it directly to the production line, applying effectively lean production, just-in-time and just-in-sequence methodologies. This enables MCC-Smart to maintain low inventory levels and to carry out the assembly process of a whole car in only a few hours.

The following case, based on [32], represents how a close relationship between suppliers and MCC supported by FMEA has improved the failure occurrence evaluation and prevention processes in the Smartville. In the Smartville, MCC and its supplier partners have been working together on a risk of failure occurrence evaluation. They have realized the constantly growing consciousness of the customer regarding the expectancy s/he has to receive conforming and failure-safe products. To satisfy this particular customer need, MCC has started a failure identification process project in collaboration with its partners. And they decided to use the FMEA technique. The cooperation of all partners is needed to systematically define the main components of the FMEA methodology: selection of the topic, agreement on its content, discussion throughout the process, and finally its release. The whole vehicle (the product) is subjected to a complete inspection throughout the development phases to discover and treat possible weaknesses. It is important for all parties to understand that the risk of failure of one partner is a part of the risk of failure of the end product. Therefore, the failure identification process requires early cooperation of the parties to identify, define and discuss possible problems that may arise. Early detection of problems and failures is important, while the changes become much more difficult and expensive as the product moves further in the supply chain.

The FMEA is started once the product is conceptualized and is available to the manufacturing areas. The first activity defined by all the parties is which system, module or component needs to be analyzed. A system structure is generated specifying the root element (i.e. the whole vehicle), the groups that correspond to this element (e.g. frame, cockpit, interiors, doors), and the components or modules corresponding to each group, until as much levels as needed are developed. The next step is to evaluate the risk of failure occurrence based on a series of questions that the team members might answer and rate based on an answers-catalog. This assessment is based on the degree to which a determined component can fail (if it is critical or not) and its possible consequences. Each selected answer has a predefined value number (weight) and according to the result it is decided whether a failure analysis is needed. Afterwards, a self-assessment by all parties involved in each process step is conducted. This assessment reviews basically the methods employed, organizational and content issues. For example, whether the timetable scheduled against to the current status is synchronized. According to the result of the assessment, the modifications and/or the agreements on the current methodology are negotiated. Finally, all the information of a module or component failure analysis is saved in a database to document the course of the whole process to consult how past FMEAs were accomplished [32].

For this particular case, the main means to maintain a close cooperation between MCC and its supplier partners has been through communication, regular meetings, and the use of common tools and techniques. They additionally have the advantage of sharing the same facility so that when a problem arises, a quick response of the relevant party allows solving the problem faster before a severe and critical impact takes place.

The most valuable aspect presented in this case is that although there are various suppliers, it does not mean that a common focus is hard to achieve; on the contrary, they worked collaboratively to improve the product and processes. They know what the final result may look like, and the benefits they will gain from this collaboration, as individual and as a supply chain. Additionally, the documentation of the FMEA project
serves as a continuous improvement tool in which experiences are documented to serve as a reference for future projects. It is a part of a collective database open to all parties which is a way of sharing information.

The Rolls-Royce Deutschland Case

Rolls-Royce Deutschland offers a complete service from development through production and in-service support for aircraft engines. In the Oberursel facility near Frankfurt am Main they manufacture among many other components, the RTM322 engines for the military helicopters that were developed in collaboration with Rolls-Royce and Turbomeca [33]. Rolls-Royce has established the Process Excellence as the basis to improve customer satisfaction and continuous improvement through the participation of all employees. Process Excellence within Rolls-Royce Deutschland is the basis of all projects and it is open to all employees. In other words, the basic criteria for a project selection are mainly its impact on customer satisfaction, business results and process performance [34].

The Rolls-Royce Deutschland Case demonstrates how the relationships, by means of information sharing, between Rolls-Royce Deutschland and its two customers have improved using SPC. Before delivery to the customer, the engine has to pass strict tests to assure the exact performance that the customer requires. These tests took place two years ago at three different locations, which made the ‘parameter acceptance process’ time consuming and costly. Rolls-Royce Deutschland proposed the implementation of SPC to monitor the most critical acceptance test parameters with the aim to reduce the cycle time for carrying out the engine test at different test stands. In order to ensure that the results obtained from the different test stands could be directly compared, a SPC data comparison of the crucial Engine Acceptance Test parameters was proposed. Some reasons why an engine can suffer performance changes or variations in different test stands can be the difference between environmental conditions where the test takes place (temperature, humidity, etc.) and transportation conditions. Therefore a procedure to standardize the data obtained at the different locations was required. Usually, in order to compare the results of each test stand, only one Engine, the so-called “slave engine”, is required to accomplish the tests (known as A-B-A test), so that the same engine with the same performance is tested in the different locations and the engine performance results can be compared. Usually the costs for these tests are very high and take approximately 6 months.

For this particular example, instead of carrying out the costly A-B-A correlation test, Rolls-Royce proposed the implementation of SPC to monitor the acceptance test engines parameters. The parameters were agreed and carried out at the three test stands. Each test stand measured its data under normal conditions, and supported by the same test stand software program, it was re-calculated according to an ISO standard scale. In this way, the data obtained enable to establish a valid system in which the parameters obtained from one test stand could be compared with those of another. That is, the results obtained from the test stands were independent of the actual environmental conditions.

According to the project owners, the cooperation between the parties improved significantly since they collectively found a mean to ease and standardize the information shared which is accompanied by financial benefits. Currently, by means of the SPC data all partners have succeeded, on the one hand, to standardize the test data among the company, customers and suppliers, and on the other hand, to fulfill their specific needs for sharing test information. The use of SPC helped significantly to reduce costs and lead times by avoiding the transportation of the test engine and running tests in the different locations and thus, offering a faster response for the product delivery to the customer.

CONCLUSION

The ultimate objective of both SCM and QM is continuous improvement of the performance and customer satisfaction, which alone is a persuasive reason to join their forces, besides their other common interests. This paper addresses that blending QM and SCM would result in higher benefits than their sole application. A valid means to do so is presenting cases from practice that help us to identify which processes, methodologies and procedures top companies from different industries implement to improve their relationships with their suppliers and customers as well as to improve the performance of their supply chain as a whole. The case studies in this paper demonstrate how applying QM techniques supported and improved SCM activities.

As presented in Table 2, by training and implementing QM techniques, supply chain activities such as integration, coordination and information sharing have been supported and improved. Cost and lead time reduction, elimination of inspection of incoming products, standardization, reduction of number of suppliers, and documentation were also positive results gained from the application of QM techniques. In the three cases, it was seen that the systematic problem-solving tools and techniques ease the solution approach of a
problem by structuring, organizing and documenting it. In fact, these tools and techniques are relatively easy to learn and can be applied in any industry.

### Table 2

Benefits gained from applying QM techniques regarding SCM activities

<table>
<thead>
<tr>
<th>Company</th>
<th>Technique</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorola</td>
<td>SPC</td>
<td>Suppliers integration, cooperation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduction of the number of suppliers</td>
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<tr>
<td></td>
<td></td>
<td>Suppliers capability measurement</td>
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<td></td>
<td></td>
<td>Elimination of incoming inspection of products</td>
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<td></td>
<td></td>
<td>Documentation</td>
</tr>
<tr>
<td>MCC (Smart)</td>
<td>FMEA</td>
<td>Partners’ integration and cooperation in early stages</td>
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<tr>
<td></td>
<td></td>
<td>Information exchange</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Early identification of failures</td>
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<tr>
<td></td>
<td></td>
<td>Documentation</td>
</tr>
<tr>
<td>Rolls-Royce Deutschland</td>
<td>SPC</td>
<td>Standardized information exchange</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost and lead time reduction</td>
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<tr>
<td></td>
<td></td>
<td>Documentation</td>
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</tbody>
</table>

Additionally, the case studies reveal that the use of QM tools and techniques enable suppliers and manufacturers to establish a common procedure to improve their activities and allows a common understanding of their needs, aims and goals. They can work together using the same tools, which ease cooperation and help them to find solutions based on the same methods. This way, they can analyze and share information obtained from common methods, which facilitates standardization and synchronization of data.

Perhaps the main limitation of this paper is the presentation of only three companies in industry. Only one out of the three cases presented was examined directly, the rest were gathered from secondary research. In addition, the paper is limited to present only two techniques, SPC and FMEA.

For future research it would be interesting to research on the one hand, how other tools and techniques (e.g. QFD, DoE,) are applied in supply chains and if their implementation has similar results as those obtained by SPC and FMEA. On the other hand, it is also required to look for cases in which the application of the tools and techniques produce a negative result, and analyze the main factors responsible for such consequences. For a successful implementation of the QM tools and techniques training is inevitable. As a general concept, training serves to transmit the corporate goal at all levels of the company, missions and quality culture principles. It also serves to strength skills by learning new methodologies and acquiring new knowledge, and above all it is a core part of any continuous improvement process. Therefore, future research might also focus on planning of the training of QM tools and techniques to support SCM activities.

## References


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November 8-9, 2007, Istanbul, TURKIYE