

**SELECTED ASPECTS OF THE RISK IN THE SUPPLY CHAIN
IN CONTEXT OF THE SUPPLIER QUALITY MANAGEMENT**

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Abstract

The introductory part of the paper underlines the importance of "Risk-based thinking" in the Quality Management System (QMS) and risk in the supply chain, as a principle part of the QMS. After introducing the key terms, the authors focused on the principle part of the article - explanation of the external and internal supply chain risks and the main factors concerning the supply risks, demand risks and environmental risks (as cardinal types of external supply chain risks) as well as the manufacturing and process risks, network/planning and control risks (as most important types of internal supply chain risks). The authors inform on the selected supply chain risk management tools, especially on those which are linked to the appropriate utilization of quality management tools.

Key words

risk, risk management, supplier, supply chain risk, quality, quality management

INTRODUCTION

Intensive competitive pressure to improve delivery performance, assurance of the products quality and time of its delivery while simultaneously reducing cost and other facts have forced organizations to pay special attention to supplier chain and supply chain management issues. International standard ISO 9001:2008 (1) in the part Purchasing underlines the necessity of supplier evaluation and selection based on the criteria for selection, evaluation and re-evaluation. Draft of new edition of this principle international quality standard - ISO 9001:2015 – confirms these facts and declares that organization shall establish and apply criteria for the evaluation, selection, monitoring of performance and re-evaluation of external providers based on their ability to provide processes or products and services in accordance with specified requirements.

Draft of ISO 9001:2015 (2) underlines the importance of "Risk-based thinking", makes risk-based thinking more explicit and incorporates it in the requirements for the establishment,

implementation, maintenance and continual improvement of the quality management system, including its utilization also in the supplier /supply chain quality issue. Concerning risk-based approach, this International Standard requires the organization to understand its context and determine the risks and opportunities that need to be addressed. The risk-based approach to drafting this International Standard has facilitated some reduction in prescriptive requirements and their replacement by performance-based requirements.

Risk analysis of the supplier/product combination should be completed prior to a customer (buyer) purchase order placement to provide visibility of risks, with a ranking according to their criticality. A method of mitigation of identified risks should be established to assure that the quality and delivery of product to the customer are unimpeded. Because supplier networks are becoming increasingly wide-spread as more suppliers across the world become available to the industry, early identification and management of those supply chain risks that could affect product/service quality becomes increasingly necessary.

The customer (buyer) should have a formal process to educate, assess and control risks in a systematic, proactive, comprehensive and cost effective manner. The organization should take into account technical and programmatic constraints.

KEY TERMS

Supplier

According to majority of professional literature, the term "supplier" is defined as a person, company, organization (set of organizations) or country, that delivers product or service (but also finances and information from a source to a customer) (3), (4). Product or service is delivered to customers (buyers, consumers), who buy and use the products (services).

Supply chain

Supply chain is a set of organizations directly linked by one or more of the upstream and downstream flows of products, services, finances and information from a source to a customer. Further very concise text of definition underlines, that Supply Chain is the process through which a company creates and distributes its products and services to the end user. It includes a number of specific elements; production planning, material sourcing, transportation management, warehouse management and demand management. These functions are tightly integrated to provide the products and services to the end user in an efficient, timely and profitable manner.

Today's supply chains are very dynamic and complex, which is due to the main following factors which characterize them:

- Faster and agile reaction to the customer requirements (growth, innovation),
- Stronger (competition),
- Cheaper (lean, economies of scale, efficient),
- Shorter time of product/service delivery
- Wider (globalization),
- Heavier (requirements, workload),
- Changing (demands, technology).

Risk

According to the ISO 31000, risk is defined as an undesirable situation or circumstance that has both a likelihood of occurring and a potentially negative consequence (5). Draft of ISO 9001:2005 defined risk as effect of uncertainty on an expected result.

An effect is a deviation from the expected — positive or negative. Uncertainty is the state, even partial, of deficiency of *information* related to understanding or *knowledge* of, an event, its consequence, or likelihood. Risk is often characterized by reference to potential “events” (as defined in ISO Guide 73:2009) and “consequences” (as defined in ISO Guide 73:2009), or a combination of these. Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated “likelihood” (as defined in ISO Guide 73:2009) of occurrence.

Risks can be expressed in terms of Probabilities and Severity. Example:

- Probability of Occurrence: Roll of a single die – 1 to 6 (with 6 being highest)
- Severity : Scale factor 1 to 5 (1 – No/Slight Impact, 2 – Marginal Impact, 3 – Some Impact, 4– Significant Impact, 5 – High Impact). Results can be expressed in a Condition matrix (Fig. 1).

High	Yellow	Yellow	Red	Red	Red	Red
Significant	Yellow	Yellow	Yellow	Yellow	Red	Red
Somewhat	Green	Yellow	Yellow	Yellow	Yellow	Red
Marginal	Green	Green	Yellow	Yellow	Yellow	Yellow
Slight	Green	Green	Green	Green	Yellow	Yellow
	1	2	3	4	5	6

Fig. 1 Condition matrix (Probability of Occurrence and Severity) (6)

Risk Management

Risk management is an iterative process to identify, assess, reduce, accept, and control risks in a systematic, proactive, comprehensive and cost effective manner, taking into account the business, costs, technical, **quality** and schedule programmatic constraints. This is illustrated in Fig. 2.

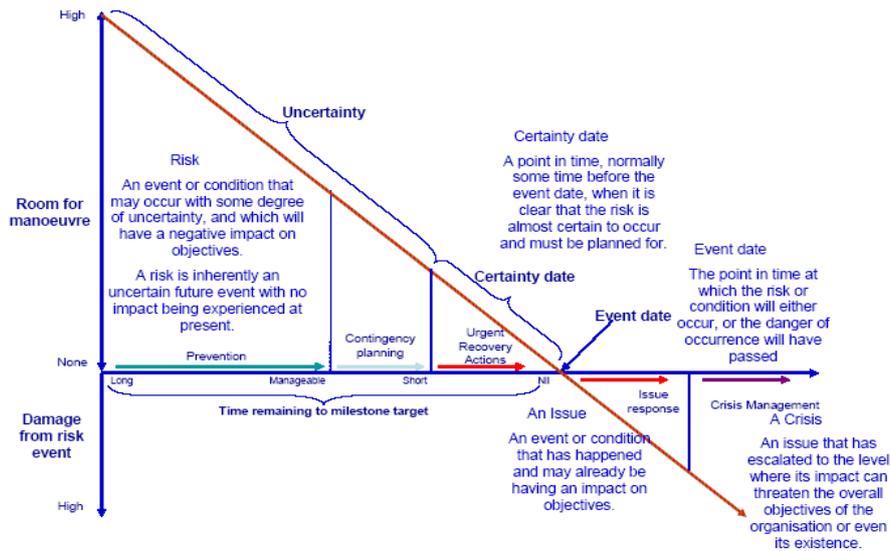


Fig. 2 Risk Management Concepts (6)

Risks are present in all activities. The impact and likelihood of occurrence varies with each risk. There is a cost, schedule and technical impact to managing each risk. Therefore, risk management is a balance of application of the correct risk management approaches to a risk, dependent on the impact of that risk. This is illustrated in Fig.3.

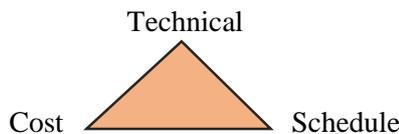


Fig. 3 Cost, Schedule, and Technical Trade-offs in Risk Management (6)

Product, service and mission benefits of the ‘organizational management of risk’:

- Reduce the likelihood of delivering nonconforming product / services to customers;
- Reduce the likelihood of delivering late product / services to customers;
- Increase likelihood of business success:
 - ✓ Increase likelihood of meeting schedules;
 - ✓ Increase likelihood of meeting budgets. To preserve the ability to make sound decisions based on potential conditions;
- Reduce the probability & consequences of mission failure;
- Reduce the probability of injury or death due to product / services failure.

Principle rules concerning risk management:

- Risk management should encompass all the areas of business performance, and should be exerted at all levels of an organization.
- Risk management is a warranty of achieving the program's objectives, based on the investigation of all unforeseen contingencies that may affect the smooth running of a program, in compliance with the quality, cost, technical and deadline commitments.
- Risk management shall deal with possible, future events; it should not be mistaken for management a current problems / issues. Risk management shall be capable, if applicable, to propose arrangements with a view to anticipation and provision of alternative solutions.
- Risk management shall be carried out methodically.

Risk Management Process

Within the risk management process, available risk information is produced and structured, facilitating risk communication and management decision-making. The results of risk assessment and reduction and the residual risks are communicated for information and follow up (illustrated in Fig. 4).

Management components typically include policies, procedures, practices, assignment of responsibilities, and sequence and timing of activities.

The risk management plan, which formalizes the objectives and policies, can be applied to a particular product, process, project, or program, and it may include part or all of the organization.

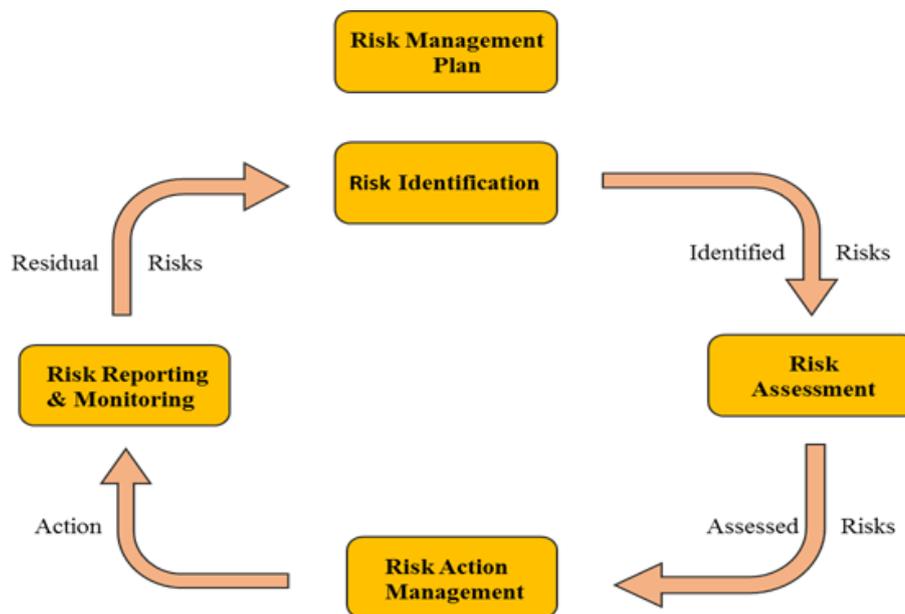


Fig. 4 Risk Management Process (6)

Supply Chain Risk Management

Supply chain risk management (SCRM) is "the implementation of strategies to manage both every day and exceptional risks along the supply chain based on continuous risk assessment with the objective of reducing vulnerability and ensuring continuity" (Cranfield University, School of Management).

TYPES OF SUPPLY CHAIN RISKS

Organization can limit the impact of supply chain disruptions on its business by identifying the risks within its supply chain and developing ways to mitigate them. It should document this process in a risk management plan, which is part of its overall business continuity plan.

There are two main types of supply chain risk (to include in organization risk management plan):

- external risks - those that are outside of organization control,
- internal risks - those that are within organization control.

External supply chain risks

External risks can be driven by events either upstream or downstream in the supply chain. There are 5 main types of external risks (7), (8):

- **supply risks** - caused especially by the following factors:
 - ✓ any interruptions to the flow of product, whether raw material or parts,
 - ✓ poor quality of supplied products, sub-systems, components, materials a.o.,
 - ✓ quality and management issues arising from outsourcing,
 - ✓ variability in lead-times,
 - ✓ delays in transportation,
- **demand risks** - caused mainly by:
 - ✓ unpredictable or misunderstood customer or end-customer demand,
 - ✓ loss of major customers,
 - ✓ volatility of demand,
 - ✓ concentration of customer base,
 - ✓ short life cycles,
 - ✓ innovative competitors,
 - ✓ inaccurate forecast,
- **environmental risks** - from outside the supply chain; usually related to the following risks:
 - ✓ macro risks (economic shifts, recession, exchange rates, custom, social, labour unrest, natural disasters),
 - ✓ climate factors,
 - ✓ policy risks (actions and sanctions of governments, shifts in legislation),
 - ✓ competition risks (uncertainty about competitors' moves and actions),
 - ✓ resources risks (lack of human resources, capital or technology),
 - ✓ no disaster management focus,
- **business risks** - caused by factors such as a supplier's financial or management stability, or purchase and sale of supplier companies,
- **physical plant risks** - caused by the condition of a supplier's physical facility and regulatory compliance.

Internal supply chain risks

Internal risks provide better opportunities for mitigation because they are within organization business's control. There are 5 main types of internal risks (7, 8):

- **manufacturing and process risks** - caused especially by the following factors:
 - ✓ manufacturing yield variability,
 - ✓ lengthy set-up times and inflexible processes,
 - ✓ breakdown of machines and equipment reliability,
 - ✓ power failure,
 - ✓ capacity shortage/bottlenecks,
 - ✓ outsourcing of key business processes,
 - ✓ problems in IT systems and warehouse problems,
- **business risks** - caused by changes in key personnel, management, reporting structures or business processes, such as the way purchasers communicate to suppliers and customers,
- **network/planning and control risks** - caused by inadequate assessment and planning, which amount to ineffective management, especially by the following factors:
 - ✓ inefficient network communication,

- ✓ poor visibility,
- ✓ inappropriate rules that distort demand,
- ✓ lack of collaborative planning and forecast,
- ✓ bullwhip effects due to multiple reasons,
- ✓ security risks - theft, data loss, counterfeiting, terrorism, piracy,
- mitigation and contingency risks - caused by not putting contingencies (or alternative solutions) in place in case something goes wrong,
- **cultural risks** - caused by a business's cultural tendency to hide or delay negative information. Such businesses are generally slower to react when impacted by unexpected events.

As you can see, more detail factors are introduced concerning three types of external supply chain risks (supply risk, demand risks and environmental risks) as well as two types of internal supply chain risks (manufacturing and process risks, network/planning and control risks), which can be consider as the key supply chain risks. Location and relationship among these types of risks in the supply chain framework are illustrated in Fig. 5.

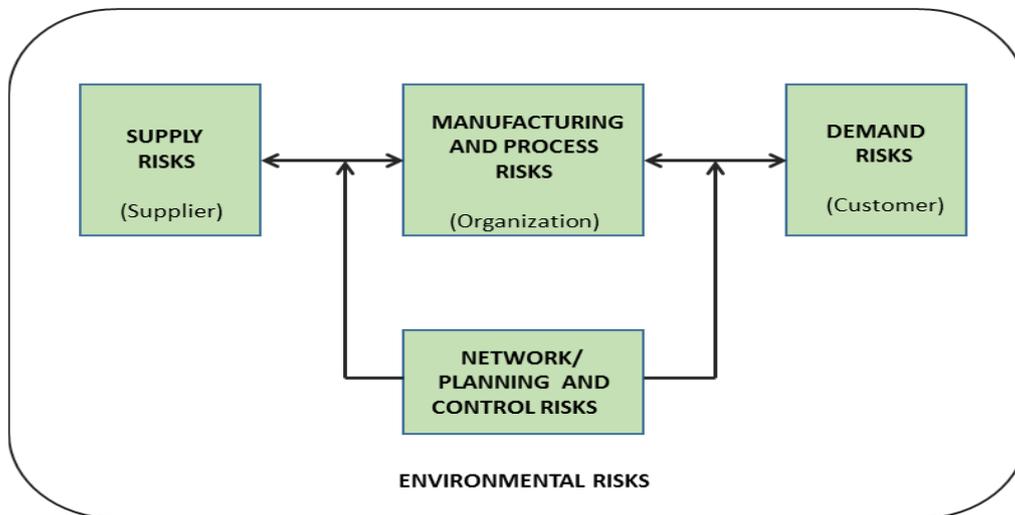


Fig. 5 Types of risks in the supply chain framework (7)

SELECTED SUPPLY CHAIN RISK MANAGEMENT TOOLS

The many of tools have been used for assuring of relevant processes and activities aims during the risk management process.

The undermentioned selected tools, including quality management tools or tools with ties to quality factors facilitate to assure the appropriate aims and realize relevant assignments during the supply chain risk management process:

- Supply chain risk mapping,
- Supplier risk table for documented risk identification,
- Utilize quality management tools for cause and effect analysis:
 - ✓ Pareto analysis,
 - ✓ Why analysis - asking "why" five times,
 - ✓ Ishikawa Diagram/ Cause and Effect Diagram (Fishbone chart),
 - ✓ Failure mode and effects analysis (FMEA),
- Supplier audits.

Supply chain risk mapping

EXAMPLE OF SUPPLY CHAIN RISK MAPPING (6)

Table 1

Risk Description	Risk type	Internal/ External	Risk Information Variables	Impact Risk Category (People, Assets/Production Loss, Environment, Reputation & Compliance)	Likelihood	Existing Control Description
Product Failure-technical	Operational	Internal	Defect percentage identified	Critical	Not Likely (less than 10%)	Quality Control and Assurance Process
Risk of significant breakdowns of Plant and Machinery	Operational	Internal	Reported Breakdowns	Critical	Not Likely (less than 10%)	Preventive Maintenance process
Inadequate Future capacity creation	Strategic	Internal	Demand vs Supply Gap	High	Not Likely (less than 10%)	Appropriate planning forecast
Delayed availability or unavailability of supplies	Operational	Internal and External	Reported unavailable	Critical	Not Likely (less than 10%)	Project Planning and Management

Supplier risk table for documented risk identification

Table 2 below shows an example of the documented risk identification criteria that may be used to identify supplier risks.

SUPPLIER RISKS IDENTIFICATION TABLE (6)

Table 2

Risk factors	Element for assessment	Risk identification tools	Risk reduction tools	
Quality	<ul style="list-style-type: none"> • Quality System Approvals/Certification <ul style="list-style-type: none"> ✓ Accredited authority ✓ Customer • Process approval/certification, • Previous supplier experiences on similar products to be identified • Current customer references, • Quality performance indicators • Contract review process 	<ul style="list-style-type: none"> • Checklists covering elements to assess risk e.g.: <ul style="list-style-type: none"> ✓ Quality system assessment with sourcing results ✓ Supplemental checklist for other elements 	<ul style="list-style-type: none"> • Continuous improvement plan agreed by suppliers with supplier mandatory indicators and corrective action request • Quality Management Plan, • Specific training on identified weaknesses and specific requirements • Selection of relevant parts • Increased products receiving inspection • Identify frozen process parameters • Assistance on site • Management of process variation (SPC) • Dual source • Buffer stock 	<ul style="list-style-type: none"> •

Environment safety	<ul style="list-style-type: none"> • ISO 14001 certification, • Hazardous products involved • Safety plant classification (if any), • Accident rating in the past years with trend • Safety policy (e.g. equipment availability, fire escape) • Training for health & safety 	<ul style="list-style-type: none"> • Specific checklist depending of nature of supply • Analysis of safety rules/controls imple-mented by supplier • Supplier action plan overview 	<ul style="list-style-type: none"> • Mitigation plan • Dual source • Buffer stock 	•
Work environment	<ul style="list-style-type: none"> • Standards/Norms requirements 	<ul style="list-style-type: none"> • Specific checklist depending of nature of supply • Quality system assessment 	<ul style="list-style-type: none"> • Preventive and/or corrective action plan • Part/process specific work environment plan 	•

Utilization of quality management tools for the cause and effect analysis

Pareto analysis

Pareto analysis is a creative way of looking for causes of problems. This technique used for decision making helps to identify the top portion of causes that need to be addressed to resolve the majority of problems. It is based on the Pareto Principle, known as the "80/20" rule. Pareto analysis is based on the idea that 80% of problems (disruptions) will share 20% of the causes.

Why analysis - asking "why" five times

1. Q. Why did the machine stop?
A. There was an overload and the fuse blew.
2. Q. Why was there an overload?
A. The bearing was not sufficiently lubricated.
3. Q. Why was it not sufficiently lubricated?
A. The lubrication pump was not pumping sufficiently.
4. Q. Why was it not pumping sufficiently?
A. The shaft of the pump was worn and ratting.
5. Q. Why was the shaft worn?
A. There was no strainer and metal scrap got in.

Repeating why five times (like in the case of above mentioned problem) can help uncover the root problem and correct it.

Ishikawa Diagram/ Cause and Effect Diagram (Fishbone chart)

Ishikawa diagram (Fishbone Diagram) or Cause and Effect Diagram is a common tool used for the cause and effect analysis, where possible causes for a certain problem or event are identified. The following Fishbone diagram (Fig. 6) illustrates the cause and effect analysis for the case of failure to deliver product on time.

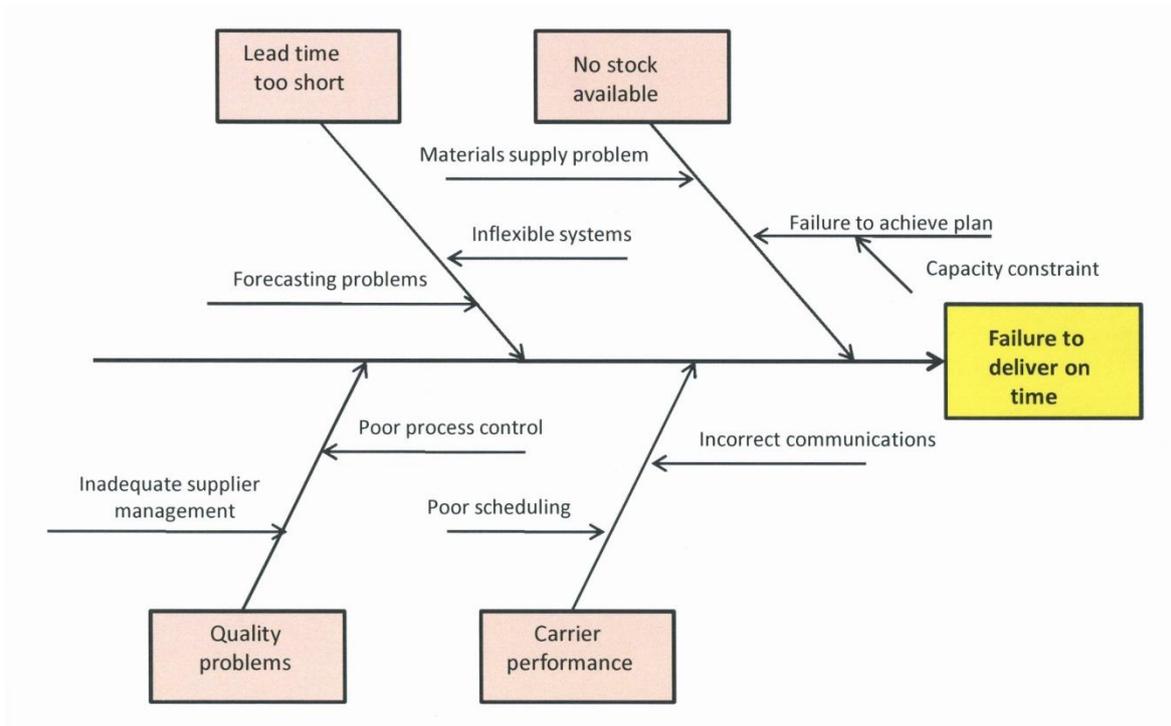


Fig. 6 Ishikawa/Fishbone diagram for failure to deliver product on time
Source: own elaboration based on (7)

Failure mode and effects analysis (FMEA)

Failure mode and effects analysis (FMEA) is used for analysing designs or processes for potential failure. Its aim is to reduce risk of failure. FMEA asks three questions: - What could go wrong?- What effect would this failure have?- What are the key causes of this failure?

The principle steps in FMEA methodology are:

- ✓ define the product design inputs or process functions and requirements,
- ✓ identify a failure mode and the potential effects of the failure,
- ✓ rank the severity of the effects (using a 1-10 scale, where 1 is minor and 10 is major and without warning),
- ✓ establish what the root cause (s) could be,
- ✓ rate the likelihood of occurrence for the failure using a 1-10 scale,
- ✓ document the present design or present process controls regarding prevention and detection,
- ✓ rate the likelihood of these controls- detecting the failure using a 1-10 scale,
- ✓ compute the risk priority number **RPN** (an assessment of risk for each possible failure):
 - $RPN = \text{severity of effect} \times \text{likelihood of occurrence} \times \text{likelihood of detection}$,
- ✓ recommended preventive/corrective actions.

Supplier audits

The external supplier audit programs are most likely involved with the procurement, performance management and risk management aspects of the supply chain. Management is always concerned about risk. The absence of a risk management program exposes the organisation to unknown problems in a reactionary mode. A risk management program allows the organizations to be proactive by eliminating problems before they occur.

The benefit of proper verification and monitoring of the supply chain include:

- reduced probability of delivering nonconforming products and services,
- increased probability of achieving organizational objectives,
- reduced probability of delivering product or services behind schedule,
- increased probability of compliance to quality, environmental, and safety regulations and the avoidance of undesirable consequences.

If there are specific identified risks and risk treatments, the audit function may be asked to verify that they are being controlled and properly treated. During any visit or interface with a supplier, an auditor has a duty to report any potentially significant risk to the audit program manager and the client.

CONCLUSION

Draft of ISO 9001:2015 underlines the importance of “Risk-based thinking” and makes risk-based thinking more explicit and incorporates it in requirements for the establishment, implementation, maintenance and continual improvement of the quality management system, including its use also in the supplier /supply chain quality issue. Risk management of the suppliers’ ability to produce compliant product or process has become a sound business practice. Assessing risk is becoming imperative to provide assurance that a “due diligence” of the supplier is completed prior to entering into a contract and customer (buyer) and supplier need to assign the responsibility for the identification, assessment and the communication of any risks discovered throughout all product/system life cycle phases (design, manufacturing, testing, inspection, delivery phases as well as during the operational and support phases). Knowledge of the supply chain risk management processes, relevant types of supply chain risk and selected tools applied in these areas is essential for the assurance of the high quality, delivery time, safety and dependability of the products, systems and technologies supplied for the customer needs.

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