

Selected aspects of the supply chain management in the aerospace industry

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Abstract: *The paper in the introductory part underlines some factors concerning the aerospace supply chain management (SCM) issue. Authors inform on selected definitions in this topic, levels of supply chain and its maturity. The authors are focusing on introducing of the explanation of main specifics of SCM in aerospace industry (original equipment manufacturer, processes and requirements for the suppliers selection) and subsequently inform on the role and mission of selected international organizations involved in aerospace SCM and quality issues, namely The Aerospace and Defence Industries Association of Europe (ASD), International Aerospace Quality Group (IAQG) and European Aerospace Quality Group (EAQG). The information on Quality Management System in the framework of aerospace industry and SCM are also introduced. The part of paper is dealing with information systems useful in the SCM (the Digital Product Chain and Enterprise Resource Planning). The last part of paper is focused on issue concerning the success factors for SCM in the aerospace industry. In the conclusion part the authors emphasize some aspects and factors regarding the aerospace SCM and summarize the key challenges in the area of SCM in the aerospace industry.*

Key Words: *Supply Chain, Supply Chain Management, Supplier, Aerospace Industry, Manufacturer, Process, Quality*

1. INTRODUCTION

The aerospace industry is in the process of shedding new light on the customer-supplier relationship, especially in the never ending quest to deliver defect free, safe and reliable product. The recognized situation is that managing suppliers throughout the aerospace supply chain remains a major challenge for the industry. To deliver high performance, technologically advanced, safe and reliable products, aerospace companies must fundamentally rethink the structure and purpose of their supply chain.

The aerospace industry continues to be challenged by increasing competition and cost pressure as well as rising energy costs, high raw material prices and impacts of the global economic and financial crisis. To combat these challenges, aerospace producers and suppliers are leveraging the advantages arising from the globalization of the aerospace supply chain. On the other hand globalization has affected today's aerospace industry with a variety of pressures, such as compressed time schedules, cost reduction, global competitiveness and increase productivity, aerospace producers have become extremely selective in choosing their suppliers and require them take on greater responsibilities in the supply chain in order to become a partner of choice and to meet the relevant requirements

and specific characteristics. In the framework of the aerospace supply chain it is an opportunity for those suppliers who can innovate, adopt high level technologies, implement best practices and invest in change – such suppliers will win larger amounts of work from the customers. To maximize the full potential of the supply chain is necessary to implement right business strategy and processes with a focus on key business objectives.

2. SUPPLY CHAIN MANAGEMENT IN GENERAL

2.1 Definitions

There is a lot of definitions of “supply chain” term, which is base concerning the term “supply chain management”. **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. [1] Further very concise text of definition underline, 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. [2]

In addition to internal functions, the supply chain also encompasses the activities of external entities, including materials and parts suppliers, manufacturers, distributors, and transportation providers. The supply chain comprises not only the movement of goods between supply chain participants, but also the flow of information and funds. Supply chain execution begins at the point a demand is created and is about the efficiency and efficacy with which that demand is fulfilled. Managing a supply chain is “supply chain management” [1] There is also a lot of definitions of this term. As accepted and useful definitions of **Supply Chain Management (SCM)** we can introduce the following two definitions:

- ❖ Supply chain management is the integration of key business processes across the supply chain for the purpose of creating value for customers and stakeholders. [3]
- ❖ Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirement. [4]

In a general we can note, that SCM is an action based on the integration of organizational units that make up the supply chain and coordinating material, information and financial flows in order to meet requirements from the perspective of end users throughout the supply chain and increase the competitiveness of the supply chain.

SCM deals with ways to effectively use information and communication technologies to support supply chain, which can lead to benefits for all participants in the supply chain. SCM as design, planning, implementation, monitoring and control supply chain activities, aims to build a competitive infrastructure, ensuring synchronization of supply with demand and performance measurement.

2.2 Key Stakeholders

In its simplest form, a supply chain is composed of the suppliers and customers of company. This is the basic group of participants that creates a simple supply chain. Extended supply chains contain three additional types of participants. First there is the supplier’s supplier at the beginning of an extended supply chain, then the customer’s customer at the end of an

extended supply chain. Finally there is a whole category of companies who are service providers to other companies in the supply chain.

These are companies who supply services in logistics, finance, marketing, and information technology. Example of an Extended Supply Chain is shown in **Fig. 1**.

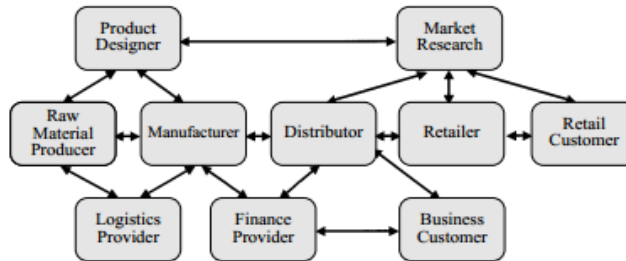


Fig. 1 Example of an Extended Supply Chain [5]

2.3 Levels of Supply Chain

The supply chain is a group of companies that provide products or services on the market contains all the phases involved directly or indirectly in meeting customer requirements. It includes not only manufacturers, suppliers but also transporters, warehouse, retailers and customers.

The supply chain is also a grouping of resources and distribution channels, which carry out functions of purchasing materials, deformation of materials to final product and distribution of finished product to the customer.

From the industry structure point of view we know the following **supplier levels** (focus on aerospace industry):

❖ **OEM** – original equipment manufacturer, refers to a company that makes a final product for the consumer marketplace

- In aerospace industry: design, development and manufacture or assemble complete aircraft (transport aircraft, combat aircraft, helicopter etc.)

❖ **Tier 1** – Tier one companies are direct suppliers to OEMs. The term refers to major suppliers of parts to OEMs.

- In aerospace industry: Sub manufacturers/assemblers – major manufacture and/or assembly of sections/systems of aircraft without designing or assembling complete units (including engines, avionics systems, aircraft interiors, landing gear etc.)

❖ **Tier 2** – Tier two companies are the key suppliers to tier one suppliers, without supplying a product directly to OEM companies. However, a single company may be a tier one supplier to one company and a tier two supplier to another company.

- In aerospace industry: Aerospace-focused suppliers (aero structures, subsystems, subassembly etc.)

❖ **Tier 3** – Broader industry suppliers – specialize in the production of particular components and in specific processes, e.g. raw material, electronic components

2.4 Supply Chain Maturity

The levels of the supply chain maturity (**Table 1**) show a progress of activities when the supply chain is efficiently managed.

Each level contains characteristics associated with factors such as appropriate level of processes management, collaboration, IT integration and others.

Table 1 Supply chain maturity levels [6]

Maturity Level	Key Characteristics	Typical Company
Controlled (4th level)	<ul style="list-style-type: none"> • SCM function is controlled, predictable and managed • Process-oriented SCM functions as opposed to traditional siloed functions • Supply chain becomes a network of collaborators as opposed to competitors • Inter-enterprise IT integration • High degree of trust and dependency 	<ul style="list-style-type: none"> ▪ Some global OEMs
Managed (3rd Level)	<ul style="list-style-type: none"> • SCM seen as part of corporate strategy • Tools and processes exist for cross-firm, cross-functional collaboration • Very strong intra-corporate IT integration • Strong supply chain visibility • Excellent communication between buyers and suppliers 	<ul style="list-style-type: none"> ▪ Multinational MRO (Maintenance, Repair and Overhaul) organizations ▪ Tier 1 ▪ Progressive Tier 2 ▪ Multi-national Airlines
Defined (2nd Level)	<ul style="list-style-type: none"> • Moderate internal collaboration across products lines • Moderate process structure • Performance management in place • Some IT integration • SCM is tactical functional 	<ul style="list-style-type: none"> ▪ Most tier 2 ▪ Small MRO organizations
Ad hoc (1st level)	<ul style="list-style-type: none"> • Limited internal processes • Ad hoc internal collaboration • Limited planning and automation • Inconsistent customer satisfaction 	<ul style="list-style-type: none"> ▪ Tier 3 and most SMEs

3. MAIN SPECIFICS OF SUPPLY CHAIN MANAGEMENT IN THE AEROSPACE INDUSTRY

Effective management of the supply chain over the last decade has helped several leading corporations gain market share, reduce costs and deliver more value to their shareholders. However, the aerospace and defence industry has lagged its peers in adopting supply chain management practices. If one digs deeper, they will find several reasons that have driven the slow adaptation of supply chain management in the industry.

By its sheer nature, the aerospace and defence supply chain is extremely complex, especially from an aftermarket standpoint. Most aircraft have a short production cycle but have a very long service cycle; sometimes as long as 30 years. This creates a service supply chain with significant requirements for maintenance, repair and overhaul and spare parts. Most parts are expensive; demand/ failure of parts and the failure location are extremely hard to predict; and customer service is absolutely critical. Many people have experienced delays when an aircraft cannot take off due to an aircraft component requiring replacement or overhaul. In addition, at every step of the supply chain there are requirements for traceability and compliance. In several instances a repairable component removed from a particular aircraft may require reinstallation on the same aircraft after repairs. To manage all these complexities, a well thought supply chain strategy is required along with good process discipline and systems that support the strategy and processes.

3.1 Original Equipment Manufacturer

In aviation terminology is usually used term Original Equipment Manufacturer (**OEM**) as an indication of the type certificate holder (**TC** – Type Certificate), which manufactures the product, such as Boeing or Airbus. Others use this term to describe such a turn the

manufacturer that supplies parts, respectively components for TC holders. This term is mostly used in the aerospace industry. The aviation authorities have no regulatory significance for this term. If you use any definition of OEM, it is important to remember that this term has not the same meaning in each area. The specific meaning of the term varies in different contexts. OEM is generally applicable to aircraft manufacturers. Examples of current OEM worldwide in this industry are Airbus – Europe, ATR – France/Italy, Boeing – USA, Bombardier – Canada, Embraer – Brazil and United Aircraft Corporation from Russia.

3.2 Processes and requirements for the selection of suppliers

Organizations operating in the production of aircraft components should do a thorough analysis of what is required to support the management of their supply chain. Once the requirements are set according to the required level of effort and resources, organizations can choose two options – build their own supply chain management infrastructure or supply chain management to ensure the service providers. For both scenarios apply to the key processes and recommended strategic, tactical and operational best practices that are worth considering when the organization is ready to introduce world-class supply chain management infrastructure.

The main processes and requirements for supplier selection are Data Tracking, Forecasting, Inventory Management, Supplier Order Management, Warehousing, Customer Order Fulfilment, Reverse Logistics (warranty and repair processing), Systems and Technology which are shown in Fig. 2.

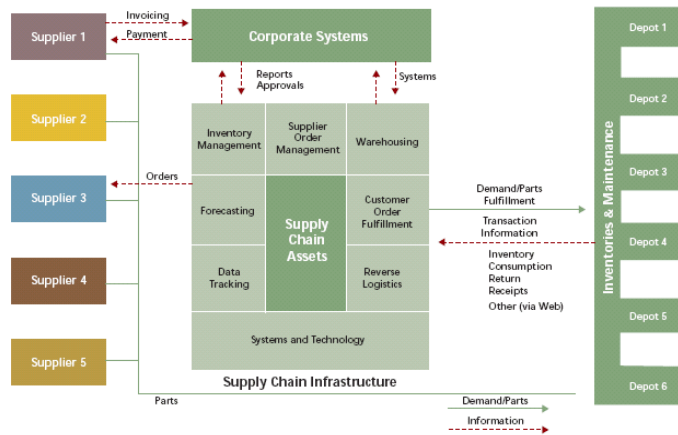


Fig. 2 Illustration of Procedures and Requirements in the Supply Chain [7]

The majority of aerospace producers have been used own requirements and specific characteristics for selection of suppliers. To become the supplier there are specific characteristics which all suppliers must demonstrate. These principle characteristics are listed below:

- Application of Total Quality Management System (especially Lean manufacturing and ACE manufacturing methods)
- Remark: The ACE (Achieving Competitive Excellence) operating system has been used particularly in USA. It is broader than the Six Sigma approach and is not as data oriented as the Six Sigma approach. ACE revolves around the three principle categories: process improvement and waste elimination tools, decision-making tools, and problem solving tools.*
- Cost competitive culture (inter alia to provide alternatives to reduce cost and add value, understand the value of low cost sourcing, flexible cash terms),

- Short cycle times,
- Financially stable,
- Progressive management, clean and visible metrics,
- Provides on-time, defect free products and services,
- Fulfilment of Aerospace Quality Specifications,
- Strong commitment to Environment, Health and Safety.

4. THE ROLE AND MISSION OF SELECTED INTERNATIONAL ORGANIZATIONS INVOLVED IN AEROSPACE SCM AND QUALITY ISSUES

Supply chain management and the quality management system areas in a general meaning and particularly from the aerospace industry point of view, as well as involvement of relevant international organizations in this areas, is very broad issue. The authors in this part of paper are focused on selected information concerning three international organizations: The AeroSpace and Defence Industries Association of Europe (ASD), International Aerospace Quality Group (IAQG) and European Aerospace Quality Group (EAQG).

4.1 The AeroSpace and Defence Industries Association of Europe (ASD)

ASD represents the aerospace, defence and security industry in Europe in all matters of common interest. The main mission of ASD is to promote competitive development of these industry sectors in Europe in partnership with the European institutions and industry associations from its member countries. ASD has 28 member associations in 20 countries across Europe. [8]

ASD's overall mission is to enhance the competitive development of the Aeronautics, Space, Defence and Security Industry in Europe in partnership with European Institutions and Member associations.

The role of ASD is to: [8]

1. Represent the European industry to promote its interests and to ensure high priority for this sector in European public policy, provide early warning on policy issues, assess impact, initiate and shape policy and develop common positions;
2. Offer a single point of contact between this industry sector and relevant stakeholders in the European institutions;
3. Facilitate the development of SMEs and the Equipment sector within **a competitive supply chain**;
4. Coordinate at the European level such services and activities as R&T, cooperative European initiatives, environment, standardisation, training/retraining, quality, airworthiness; assess human resource and skills as well as social impact, promote trade in coordination with National Associations, sponsor workshops/conferences initiatives;
5. Promote international cooperation, lead the dialogue with other International Associations and Organisations and represent the European Aerospace and Defence industry towards the industry of other countries/regions where a European common denominator exists.

ASD's affiliated associations ASD-STAN and ASD-CERT [8] form the quality-related SERVICES of ASD. The purpose of ASD-SERVICES is to contribute to improvements in quality and to reduction in costs throughout the value stream by maintaining cooperation between European aerospace companies in business areas.

ASD-STAN (Product standards and Technical Specifications) establishes, develops and maintains standards requested by the European aerospace companies. It is well recognized as the European Body for the development of global Aerospace standards by the International Aerospace Quality Group – IAQG (under mentioned) and it is also the sole provider for Aerospace standards to CEN as its most active committee.

ASD-CERT (Certification of Standard Aerospace Products) audits and qualifies the conformity of the production of standard products with the related standard technical specification. This is based upon **EN 9133 "Qualification Procedure for Aerospace Standard Parts"** and the principles described in the **ASD-CERT Quality Manual** and in the **ASD QC 24281 Quality Document**. The resulting **QPL "Qualified Product List"** is published on the ASD-CERT webpage. Pre-requisite for an ASD-CERT Product Qualification is a certified/registered QMS according to AS/EN/SJAC 9100 being in place at the supplier of the standard product. **ASD-CERT Production Qualification Certificates** are recognized by all major European Aerospace co companies.

4.2 International Aerospace Quality Group (IAQG)

The IAQG is a cooperative global organization that brings aviation, space and defence companies together to deliver more value at all levels of the supply chain. [9]

The mission of IAQG is to achieve significant performance improvements in *Quality*, *Delivery*, and consequently *Cost*, on all products and services throughout the value stream through the establishment of effective prevention oriented practices and processes, by standardizing Requirements, providing Process Guidelines and spreading Best Practices, by introducing a *Culture of Quality* as early as possible in the value stream thus reducing the cost of poor quality and through establishing and maintaining dynamic cooperation between international Aviation, Space and Defence companies.

IAQG visions for the next 5 years: [9]

- ✓ Product and Services Quality and Delivery will have improved 20% per year throughout the product lifecycle,
- ✓ Robust processes achieved throughout the supply chain (Supply Chain Management Handbook Maturity Level 3 or better),
- ✓ IAQG Quality Management System certification program is robust, recognized and valued,
- ✓ 90% of the supply chain certified to IAQG Quality Management System Standards.

4.2.1 The Supply Chain Management Handbook

Supply Chain Management Handbook (**SCMH**) is provided by the International Aerospace Quality Group (IAQG) on its website to help with the development of quality procedures. To follow this manual is not binding, the implementation procedures of this manual is based on a voluntary basis and its suitability for a particular use is the sole responsibility of the user.

Nevertheless, this manual is provided free of charge to organizations at all levels of the supply chain and provides a lot of valuable advices how to manage supply chains, define the quality requirements of suppliers, sub suppliers, describes the quality requirements of critical and noncritical components, defines marketing and planning, design and development of components, provides an analysis of the problems causes and solutions in the supply chain.

The manual is structured into 11 main chapters, in which are defined business supply chain processes and product life cycle, where each company can draw a lot of valuable information how to effectively manage the supply chain and what needs to be met for its manage. Illustration Handbook is shown in **Fig. 3**.

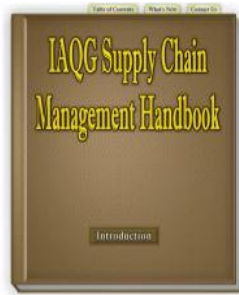


Fig. 3 Illustration of Supply Chain Management Handbook [9]

The handbook was published in October 2008 and has since been constantly updated and improved by IAQG experts dealing with supply chain management in depth.

4.3 European Aerospace Quality Group (EAQG)

EAQG is the European sector of IAQG and the Quality community of ASD. EAQG is a cooperative European global organisation of companies (34 European major companies and 10 National Trade Associations) providing Aviation, Space and Defence products and services on time, on quality and on cost for the customer satisfaction. [10]

EAQG purpose is to implement initiatives that make significant improvements in Quality and reductions in cost throughout the value stream by establishing and maintaining dynamic co-operation based on trust between international aerospace companies. [10]

Aerospace Performance Improvement (API) is the EAQG services platform established to provide the Industry (Aerospace & Defence) Supply Chain. Its main aim is to improve the performance of the whole Supply Chain by focusing on all the best practices developed by the Industry through the IAQG.

The proposed services are delivered by independent Service Provider companies selected by EAQG and working with EAQG through a partnership with aim to provide all Supply Chain companies with the right tools to achieve the performance improvement. Services covering the field of Quality by implementing a robust Quality Management System (QMS) and the best practices of the main Supply Chain processes in order to achieve significant improvements in terms of Quality and reductions of costs.

5. QUALITY MANAGEMENT SYSTEM IN AEROSPACE INDUSTRY AND SCM

The process of quality management can be used at all stages during the life cycle, focusing on the implementation of management processes and improve them as needed. This process includes the activities of planning, investigation, auditing, measurement and monitoring, verification and preventive actions.

Costs incurred in ensuring and demonstrating the good quality must be balanced against potential costs estimated a loss caused by not achieving a satisfactory quality. Quality management activities must be used for all aspects of the process according to the requirement of the standards and requirements specified in the contract.

5.1 Stages and processes of life cycle

The basic standard for life cycle management system issue is **ISO/IEC 15288** “Systems engineering – System life cycle processes”. According to this standard the life cycle is

divided into clearly defined six stages: Concept, Development, Production, Utilization, Support, Retirement (Disposal). [11]

At each stage of the life cycle there are processes that can be used all over the organization or specific to the project. The life cycle participants should establish, document, maintain and improve the effectiveness and efficiency of processes. Organizations can to the arrangement and adapting the processes appropriate way to apply international standards in relation to the structure organization, plans and business strategy. These standards could also include criteria to confirm the successful implementation of processes.

5.2 Requirements for quality suppliers

To ensure customer satisfaction is important for organizations to continuously improve aviation safety and reliability of its components that meet regulatory requirements. The globalization of the aviation industry and the diversity of regional and national requirements have complicated the achievement of this goal.

Organizations to meet the challenge of quality assurance and integration of components purchased from suppliers around the world and at all levels within the supply chain. Aircraft suppliers and processors are supplying components for multiple customers meet the challenge of ever-changing quality requirements. Hence the need for compiling a uniform standard, which aims at integrating the requirements for quality management system for aerospace industry and establish a common requirement for organizations at all levels of the supply chain throughout the world and led to an improvement in quality, safety and cost reduction through the elimination of specific quality requirements individual organizations.

This raises the internationally recognized quality system standard specific to the aerospace industry. In North America, known as AS 9100, in Europe EN 9100, in Japan JISQ 9100 and its strict adherence is supported by major aircraft manufacturers including Boeing, Airbus, Bombardier, Pratt & Whitney, Lockheed Martin, Goodrich, Messier-Dowty, GEAE, Rolls-Royce, etc.

5.3 AS 9100

Standard SAE AS 9100 - Aerospace-Quality Management Systems Requirements - was first put into practice in October 1999 (revision A), issued by Society of Automotive Engineers (SAE) and the Aerospace and Defence Industries Association of Europe (ASD) and on the base of efforts of the International Aerospace Quality Group (IAQG). The standard was combine and harmonize with the requirements of ISO 9001 (for illustration shown in **Fig. 4**). AS 9100 certification has become a basic requirement that all companies require from their suppliers. AS 9100 of the current revision C (2009) based on the basic standards ISO 9001, supplemented by additional requirements specific to the needs of aerospace. It specifies requirements for the aviation industry in an effort of continuous quality improvement and selection of suppliers and quality assurance in all parts of the supply chain in the aerospace industry. Based on the requirements of ISO 9001 and AS 9100, the emphasis is put on quality, safety and technology in all industries across the supply chain.

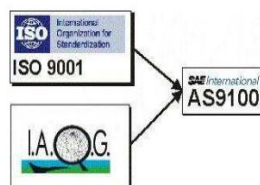


Fig. 4 AS9100 – ISO 9001 and additional Aerospace requirements identified by IAQG [12]

5.4 Risk Management

Supply chain in the aerospace industry needs a radical change from the ground at present. Suppliers of first- and second-level manage huge part of subsystem integration and also a huge segment of the supply chain. Today more than ever, programs either fail or succeed because of the supply chain equipment. Many suppliers have gained a lot of benefits using the new supply chain model, but management risk systems were suppressed in their limits.

In recent years, inefficient supply chain risk management has caused cost overruns, production delays, quality reduction and also job plans interferences. Still searching rising international cooperation and customers has caused even more complicated risk. Individual suppliers were unable to respond to these risks and also the current processes and controls from major suppliers. Such action in isolation meant that there were still other problems in the supply chains. Successful companies have looked for ways to do better by sharing of risk information and coordinated distribution of risk, which can minimize any unpleasant surprises, improve work plans performance and reduce costs.

Risk Management Plan is being developed through the following three best practices:

- a) Number of participants in the program risk management has increased, making up more and more internal functions and members of the supply chain. The program allows adding low-cost suppliers and a wider range of stakeholders in order to identify potential risks, understand it, adequately respond to it and then monitor the effectiveness of response.
- b) Executives learn how to predict the risk, how to recognize, interpret it and monitor early warnings of potential signs that could be the problem and change the risk profile.
- c) Companies changed corporate culture. Trainings, new responsibilities, encouraging new employees and suppliers have come to evading the reportable of risk until they have no solutions or did not understand the risk like someone else's problem.

Better identification of risk and comprehensive information has fallen on benefit overtime. More comprehensive responses to the origin of risk also bring the benefits. Costs for the delay decreased, the return on investment is increasing and suppliers are delivered on time to meet.

6. INFORMATION SYSTEMS USEFUL IN THE SUPPLY CHAIN MANAGEMENT

Information systems allow efficient transmission, processing and storage of information up to the automatic identification for supervisory control in manufacturing, transporting and storages (e.g. radio frequency data communications from anywhere in the company allows communicate with the control computer or satellite communication in maritime, air and truck transport, in container terminals) for remote communication between suppliers, logistics services providers and customers (**EDI** - Electronic Data Interchange).

Just as large companies, small and medium enterprises need integrated enterprise software systems that support them effectively in the implementation of business objectives and in the future will be for them a reliable management tool. Many business solutions developed over the last 30 years as Enterprise Resource Planning (**ERP**), Customer Relationship Management (**CRM**) and Supply Chain Management (**SCM**) focused on the exchange and information management about the physical product. They were designed primarily for automating repetitive operations. These applications are suitable for activities involving the implementation of repeated the same activities in the same way again and again. But they are poorly adapted to the needs of rapidly recurring operations and product innovation, which is characterized by Product Life Cycle Management (**PLM**).

6.1 The Digital Product Chain

Manufacturing companies are the first to recognize the value and output of the Digital Product Chain, as shown in Fig. 5. This chain shows how development teams collaborate in the creation of information, as well as changes that are essential for the new, respectively innovative product. Through work with 3D digital data (portfolio Creo Elements/Pro, before Pro/ENGINEER) teams can experiment, make changes, work with the products options, improved designs, variants etc. By inclusion all bystander in this process with a specific overview of the flow of product data and information products, these may be in digital form complete before starting costly physical production process.

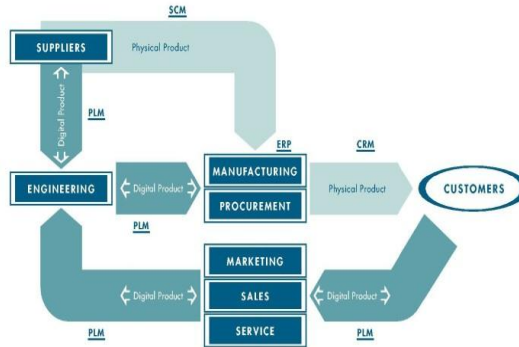


Fig. 5 Diagram of Digital Product Chain [13]

SCM- Supply Chain Management; PLM- Product Life Cycle Management; ERP- Enterprise Resource Planning; CRM- Customer Relationship Management

6.2 Enterprise Resource Planning

Enterprise Resource Planning (ERP) is application software that enables the management and coordination of available business resources and activities. It can be performed internationally. ERP means complex information systems of enterprises, which include activities related to production, finance, accounting, supply chains – SCM, creating and strengthening relationships with customers – CRM (Customer Relationship Management), human resources management and so on. ERP systems are designed to integrate key operations across the enterprise from planning to implementation, management and control. ERP aims to improve and streamline internal business processes.

There are several reasons why enterprises begin with ERP projects and implementation of ERP systems. The main reason for implementing ERP systems is to increase business performance. Changes in technology and thus the implementation of the ERP system directly affect the daily work and processes of individual employees. Information system changes in the company at the beginning of implementation necessarily associated with a temporary loss of productivity and motivation, but effective change management helps to minimize risk. There are several ERP systems, which can companies to implement, review the most widely used in worldwide shows Table 2.

Table 2 An overview of the most widely used ERP systems in the world [14]

Serial No.	Name of ERP system	% representation
1	SAP	31
2	Oracle	22
3	Microsoft	22
4	Sage	3
5	Exact	3

6	Infor	2
7	Lawson	2
8	Consona Corporation	2
9	QAD	2
10	Others	11

7. SUCCESS FACTORS FOR SUPPLY CHAIN MANAGEMENT IN THE AEROSPACE INDUSTRY

Today OEMs recognized that they are forced to develop and implement new skills and toolboxes to monitor, steer and support the complex supply chains and development networks. The increasing numbers of stakeholders in such supply and development networks enforce different supply chain capabilities reaching from optimization, integration, collaboration to synchronization to master the growing complexity. *Supply chain synchronization* strives for full transparency and availability of information, joint optimization of processes and interfaces and has the highest capability to handle complexity. *Today's aerospace supply chain management is mainly focused on improving integration and collaboration capabilities* but it needs to get ready for a paradigm change to enable systematic synchronization.

Supply chain configurations/typologies can be distinguished along the two axes of “strategic relevance of the supply chain” and “supply chain complexity” (as shown in **Fig.6**). Following this distinction we know four kinds of supply chain configurations/ typologies: Efficient, Accurate, Responsive and Agile. [15]

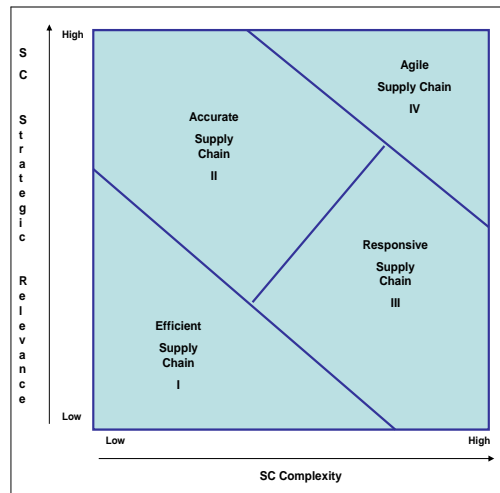


Fig.6 Supply Chain (SC) configurations/typologies [15]

The efficient supply chain (I) is characterized by low complexity combined with supply chain management having a low strategic relevance for the organization. An efficient supply chain is not a suitable typology for the aerospace industry. **The accurate supply chain (II)** is also characterized by low to medium complexity, but where the supply chain has medium to high strategic relevance. In contrast to the efficient supply chain typology, a failure in the supply chain can have significant impact on the whole organization. Hence, the supply chain management has not only to comply with efficiency requirements, but it needs

to be trustworthy, reliable, and transparent. Complexity remains low since production quantities are relatively small, supplier basis is stable and development cycle are moderately long. **The responsive supply chain (III)** is characterized by high complexity and low to medium strategic relevance. Responsive supply chains aim at maximizing the performance for a specific and dominant partner in the supply chain by increasing efficiency through defined processes and rules. **The agile supply chain (IV)** typology is distinguished by high levels of supply chain complexity and by high strategic relevance. A failure in the supply chain/ supply chain network can have significant impact on overall performance. Hence, the requirements for control and reliability increase. Despite this, the speed for rapid reaction enforces decentralized decision-making. High diversity and specificity of resources, products, suppliers, and customers results in strategic interdependencies that need to be managed.

Today's aerospace supply chain configuration is in a transition from a responsive supply chain to an agile supply chain. We can identify the following key success factors to strengthen supplier management and establish an agile supply chain configuration in the aerospace industry: [15], [16]

1. **Improve Flow Management** between OEM and suppliers in all stages of the product/system life cycle by:
 - professionalizing interfaces through improved reporting processes and end-to-end responsibilities,
 - defining and applying strict and shared rules (e.g. shared and stable design rules in development phases, clear quality and test procedure definitions),
 - reducing volatility in the supply chain through more robust planning.
2. **Develop Supplier Portfolio** by:
 - establishing transparent and reliable risk and performance evaluation through shared assessment criteria's and early communication of bottlenecks,
 - synchronizing information flow through suitable IT solutions,
 - setting a clear vision of target supplier portfolio.
3. **Improve Supply Chain Design** by:
 - focusing on key suppliers with the right capabilities,
 - assessing robustness of the supplier network,
 - leveraging best practices and supplier know how through the whole network.
4. **Develop Strategic Suppliers** by:
 - establishing high degree of trustworthy collaboration (e.g. risk sharing partnerships, joint improvement programs, open book policy, on-site representatives,
 - transferring knowledge by co-location of critical teams and ramp up supplier capabilities.
5. Pay a special attention to **education, preparation and training of** the supply chain management/ purchasing **staff**, because well-trained and open-minded staff in this area are at least as important as strategies and tools. The SCM team is crucial for the success of an innovative customer- oriented aerospace industry organization.

8. CONCLUSION

Aerospace industry with its high technology is one of the major contributor to the economic development and it is from a lot of reasons strategically important sector. Principle importance for its functionality and futher development, as well as from the flight safety and

reliability of the aviation equipment point of views has the capacity, maturity level and other factors related with the supply chain management (SCM) in the aerospace industry. For aircraft safety reason, each aircraft-related parts needs to be certified by the aviation authorities and requires full traceability back to origin. These high standards for production and approval of parts, as well as other quality regulations for suppliers, in combination with high investment costs, generate an overall highly oligopolistic – and, for key parts, even monopolistic – market structure for the supply of aircraft parts and services. [16]

The future challenges to survive changing conditions and install efficiently working aerospace supply chain networks is a matter of active change management within the organization. For an organization, understanding its supply chain management requirements is the first key step. Once the requirements are clear, the next step is deciding whether to build a supply chain infrastructure in-house or partner (s) with a supply chain product/services provider. The processes concerning the SCM and quality management systems in the aerospace industry, as well as the reflection of strategic, tactical and operational best practices, can then be utilized to implement a successful supply chain management solution in the framework of organization.

The aerospace industry would take into account the following **key challenges in the supply chain management for the near and middle future**: [15], [16], [17]

- *Increasing level of integration* (e.g. risk sharing, development partnership, supplier pre-assembly).

Due to this fact program management is seriously concerned with aligning development and industrial ramp-up with supply chain partners. Resulting key challenge for supply chain management is to move from a fire fighting mode to anticipation and better managed interfaces.

- *Significantly increased supply chain complexity.*

The impact of this factor on supply chain management is critical. SC managers struggle to achieve an optimum between cost targets, offset requirements, quality standards, currency volatility reduction and operational efficiency.

- Principle importance of *innovation and research and development (R&D)*.

Increasing competitiveness and rising consolidation pressure as well as shortening technological development cycles are one of the most important factors for the aerospace industry. Especially due to fact that R&D responsibilities were pushed to sub-tier suppliers, new challenges in managing joint design processes and configuration changes occur in the supply chain.

- *Supplier selection and capability assessment*, covering the risk for engineering and design capability, manufacturing (by commodity), supplier's capacity management, planning and financial health, software capability, in-service support and use and management of electronic data and e-tools.
- *Development of supplier capabilities and proper motivation* to improve processes, detect weakness in suppliers before they cause a disruption in the supply chain and quickly react to and recover from supplier problems.
- The necessity of stringent *supply chain coordination and standardization*.
- The *performance and efficiency of the supply chain itself*.

The effort of authors was to contribute through the selected and beneficial information focused on the supply chain management in the aerospace industry area to the professionals and the public interested in this important issue.

REFERENCES

- [1] J. T. Mentzer et.al., Defining Supply Chain Management, in *Journal of Business Logistics*, Vol. 22, No.2,2001.
- [2] W. Scott and Ch. Oldfield, *The Nine Basic Rules of a Successful Supply Chain*
URL: <http://www.aia-aerospace.org/assets/smc_wp-nine.pdf>
- [3] D. M. Lambert, *Supply Chain Management: Processes, Partnership, Performance*, 3rd edition, 2008.
- [4] D. Simchi-Levi, P. Kaminsky, E. Simchi-Levi, *Designing and Managing the Supply Chain*, 3rd edition, Mcgraw Hill, 2007.
- [5] *Basic Concepts of Supply Chain Management*,
URL: <<http://catalogimages.wiley.com/images/db/pdf/R0471235172.01.pdf>>
- [6] KPMG, *Aerospace Supply Chain Management*, 2009,
URL: <http://www.aiac.ca/uploadedFiles/News_and_Events/Calendar_of_Events/agm/KPMG-EDC_Presn_to_09_AIAC_AGM.pdf>
- [7] *Managing the Aviation and Defense Supply Chain*,
URL: <<http://mthink.com/article/managing-aviation-and-defense-supply-chain/>>
- [8] *The Aerospace and Defense Industries Association of Europe (ASD)*, URL: <<http://www.asd-europe.org/>>
- [9] International Aerospace Quality Group (IAQG), URL: <<http://www.sae.org/iaqg/>>
- [10] European Aerospace Quality Group (EAQG), URL: <<http://www.eaqg.org/>>
- [11] International Standard ISO/IEC 15 288, *System engineering-System life cycle processes*
- [12] <<http://www.tfzr.uns.ac.rs/emc2012/emc2011/Files/B%2002.pdf>>
- [13] *Komplexný systém vývoja výroby*, URL: <<http://www.ipmsolutions.sk/showdoc.do?docid=217>>
- [14] *Systém ERP. Popis a prípadové štúdie*,
URL: <http://147.232.5.199/orsag/index.php?option=com_content&view=article&id=79:erp-popis-a-pripadove-tudie&catid=40:podporne-it-nastroje-v-manamente&Itemid=78>
- [15] M. Hader, J. Wahler, A. Schwandt, R. Berger, *Key success factors in aerospace supply chain management*, in AVIATION FORUM 2011, *The supply chain conference in the aerospace industry*.
URL: <http://www.ipm-scm.com/download/scma_2011_iii.pdf>
- [16] J. Rissiek and J. Kressel, *New Developments in Purchasing and Supply Chain Strategies for the Aviation Industry*, URL: <http://www.touchbriefings.com/pdf/199/ifpm032_p_rissiek.pdf>
- [17] D. K. Gordon, *Supply Chain management remains Aerospace Challenge*,
URL: <<http://asq.org/quality-progress/2006/07/standards-outlook/supply-chain-management-remains-aerospace-challenge.html>>
- [18] K. Richter, *Globalising the Aerospace Supply Chain: The Airbus Approach*, in AVIATION FORUM 2011, *The supply chain conference in the aerospace industry*.
URL: <http://www.ipm-scm.com/download/scma_2011_iii.pdf>
- [19] I.Koblen and S.Szabo, *Selected aspects of life cycle cost issue for defence and aviation systems*, in AFASES - 2010: Scientific research and education in the air force: *The 12th international conference of scientific papers: May 27-29, 2010, Brasov, Air Force Academy, Romania*, p. 1-8, ISBN 978-973-8415-76-8
- [20] A. Behrens, *Managing the supply chain across the aerospace life cycle*, 2010,
URL: <http://m.plm.automation.siemens.com/en_us/Images/21676_tcm1224-99260.pdf>
- [21] *Hamilton Sundstrand Supply Chain Management*.
URL: <<http://www.hamiltonsundstrand.com/About+Us/Supply+Chain+Management>>
- [22] *CATIA for Aerospace Supply Chain*,
URL: <<http://www.3ds.com/fileadmin/PRODUCTS/CATIA/OFFERS/CATIA-FOR-AEROSPACE-SUPPLIERS/PDF/CATIA-for-aerospace-supply-chain-brochure.pdf>>
- [23] <<http://as9100store.com/AS9100-Requirements.aspx>>
- [24] <<http://www.dnvba.com/sk/certifikacia/Manazerske-systemy/Kvalita/Pages/AS-EN-9100.aspx>>
- [25] <<http://dspace.mit.edu/handle/1721.1/17898>>