Coordination in collaborative manufacturing mega-networks: A case study

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Abstract

Collaborative manufacturing networks are becoming popular. Today, the scale of these networks can be enormous, and include a complex myriad of partners from numerous companies and organizations spanning several countries and even continents. This paper explores how these partners successfully coordinate projects through an investigation of one such “collaborative manufacturing mega-network” or CMMN in the commercial aerospace industry. The case is analyzed with the aid of the literary state-of-the-art, and a number of organizational, structural, and cultural issues are discussed including mass customization. Finally, some of the most important factors for the successful CMMN are presented.

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1. Introduction

Today’s extremely turbulent, global and cross-industrial business climate is frequently characterized by corporate merges, acquisitions, and strategic alliances, a situation that has forced organizations to integrate and find new and efficient ways of working and
communicating with each other. Companies are increasingly cooperating in what are often referred to as “collaborative manufacturing networks”, structures that have enabled companies to focus on their core competencies and yet still participate in the design and/or manufacture of large systems. Collaborative manufacturing networks are viewed here as extended enterprises consisting of several companies that cooperate in a project resulting in a manufactured product, where each company has expert competencies in one or several areas.

There are a number of issues to consider in the study of collaborative manufacturing networks, such as their structure and organization, how they coordinate and plan for resources, material and competence, and the relationships of each network player to external partners, such as suppliers, final customers and other entities. The nature of the products/systems produced by these networks must also be taken into consideration. Customer requirements for mass-customized production, for example, are strong in both the Business-to-Consumer (B2C) and Business-to-Business (B2B) markets. Mass customization is a popular term for the manufacturing strategy characterized by greater product diversity and individualization at or near mass production efficiencies (Pine, 1993). Such a strategy can add complexity in terms of information and material flows and entail greater planning and coordination challenges—especially for a dispersed network.

The scale of these networks can be enormous, hence “collaborative manufacturing mega-networks” (CMMNs), and include a complex myriad of partners from numerous companies, organizations, and institutions spanning several countries and even continents. Not much is known, however, about the coordination of CMMN partners in a successful project. In this paper, the requirements for this unique type of mega-network collaboration are investigated based on an interview study at the Swedish aerospace manufacturer Saab, a key factor in a global consortium for the development of a new aircraft, the Airbus A-380. The case, which is considered here as a prime example of a mega-network, is analyzed with the aid of the literary state-of-the-art, and a number of organizational, structural, and cultural issues are discussed. The demands on such a network structure given the current trend towards mass customization are also addressed. The study is concluded with a discussion of observations from the case, which illustrate some of the most important factors for the successful CMMN.

2. Theoretical framework

In this section, five dimensions related to CMMNs are reviewed based on a sampling of the relevant literature. These dimensions, in turn, were used as a framework for the subsequent analysis of the industrial case, as described in Section 4. While the first four dimensions describe the CMMN’s different characteristics, requirements and challenges, the final dimension considers the product it produces, taking the case of mass customization as a practical example. The theoretical frame’s different dimensions, with corresponding text section numbers in parenthesis, are illustrated in the conceptual model below:

In Fig. 1, the customer and its product/system, as in other customer-centric models (see, for example, Ayers, 2002), take center stage. In order to support the customer’s requirements for a particular product/system, Fig. 1 illustrates that a suitable network
strategy must also be chosen. This strategy, in turn, is related to the network’s structure, its culture and extent of knowledge sharing, and ultimately how it communicates. Finally, the conceptual framework is illuminated with the practical scenario of mass customized production. Customer requirements, in this case for customization, affect not only the final product, but every dimension of the framework—from the network’s strategy to how it communicates.

2.1. Network strategy

Fleury and Fleury (2003) assume that there are three different strategies through which companies compete in the market: through operational excellence, product development or a customer-driven approach. Furthermore, they argue that given today’s new competitive requirements, individual efficiency is not enough; rather, it is necessary to be connected to groups of firms that are collectively efficient. To become a participant in an inter-organizational network, they write that firms would have to negotiate resources, infrastructures, intangible assets (e.g. brand name) and organisational competencies. Loeser (1999) mentions that a very promising approach for expansion into new markets is through cooperation with other enterprises, which could be enterprises with complementary competencies, in order to increase critical competencies and diversification (Winroth et al., 2003; Johansen and Björklund, 2003). Companies, of course, can cooperate in many different ways, and there is a wide spectrum of alliance types, ranging from technology-transfer agreements to strategic alliances to joint ventures (Fleury and Fleury, 2003). In general, companies form alliances in order to obtain technology, to gain access to specific markets, to reduce financial risk, to reduce political risk, and to achieve or ensure competitive advantage (Wheelen and Hungar, 2000). Strategic alliances are popular when firms want to share risks and exchange resources, access new markets, achieve economies of scale and obtain synergy and competitive advantages (Dacin et al., 1997). However, the failure rate of strategic alliances has been projected to be as high as 70% after 3 years (Elmuti and Kathawala, 2001; Chan,
Elmuti and Kathawala (2001) cite a McKinsey study that found that half of such failures were due to poor strategy, while the other half had poor management as the cause. Often, the financial risk in pursuing a new product or production method can be too difficult or costly for a single company to undertake; thus, it is not unusual for two or more companies to come together in order to spread the risk between them (Das and Teng, 1999; Elmuti and Kathawala, 2001). Das and Teng (1999) argue that the protection of primary resources, property (physical, financial) and knowledge (technological, managerial) should be a priority in an alliance. They also mention that the two primary risks in an alliance are relational risk and performance risk.

2.2. Network structure

There are several ways in which to structure a collaborative manufacturing network, or in this case, a CMMN. The two traditional ways are either through vertical or horizontal integration (De Wit and Meyer, 2002, pp. 513–515). The four main categories in these relationships are defined as follows:

- Upstream vertical relations, which are based on the premise that each company has suppliers of some sort.
- Downstream vertical relations, or in other words the “output side”, where the company and/or organization has a relationship with its customers or buyers.
- Direct horizontal relations, which describe the relationship between the company and/or organization and other industry players, with these actors as competitors producing similar goods and services on the same level.
- Indirect horizontal relations, where the company and/or organization have a relationship with a company outside its own industry segment.

Scott (1996) argues that networks may be horizontal (across a domain of complementary technologies), vertical (covering an industrial sector) or diagonal (cross-sectoral, such as focusing on bridging technologies). Many companies, in fact, are moving away from vertical integration, where all operations and logistic issues are handled from the inside. Increasingly, the emphasis is on external and horizontal cooperation connecting all members of a supply chain, i.e. both geographical and functional (Azevedo and Sousa, 2000). However, some practitioners have other philosophies, with some companies striving to keep between 40 and 50% of the value-adding activities in the company in order to guarantee quality and cost efficiency, as is the case at the Swedish Scania according to an interview of their production manager (Hallberg, 2002).

2.3. Network culture and knowledge sharing

The last decade has seen the rise of the extended enterprise: companies working together in intimate, trust-based relationships to develop, produce and deliver complex products (Dyer, 2000). Dyer argues that a trust-based relationship saves money when compared to an arms’ length relationship. Furthermore, Dyer contends that building this
kind of collaboration requires time and commitment. In order to build such a collaborative relationship, the partners must be willing to invest in people and assets that are dedicated to each other, and also be prepared to share both explicit and implicit knowledge with other companies—companies which may also be competitors (Dyer, 2000). These collaborative relationships are, according to Dyer, trust-based rather than contract-based, as detailed contractual agreements can waste time and resources, while failing to address all potential problems. Elmuti and Kathawala (2001) mention that building trust is the most important and yet most difficult aspect of a successful alliance, since only people can trust each other, not companies. These authors continue that companies must work to enhance the three forms of trust—responsibility, equality and reliability—at the individual level.

The allied companies need to capture the alliance’s insights and experiences, codify the alliance’s management lessons and best practices, communicate person-to-person to obtain the know-how that is more tacit in nature, and create guidelines and training programs to finally coach the organizations within the alliance (Skyrme, 1999). Skyrme (1999) provides an example of knowledge networking, which concerns openness and collaboration across departmental, organizational and national boundaries. This knowledge networking, in combination with the importance of trust mentioned above, is especially important to manage within CMMNs. Kilburn (1999) notes that many of the cultural problems faced by corporations in alliances today have their roots in issues related to languages, egos, chauvinism, and different attitudes to business. With respect to Savage’s (1996) view that time-to-learn is as critical as time-to-market, the importance of building trust and teaching the collaborating individuals about cultural differences in order to not risk delayed time-to-market becomes clear. To summarize, Ohmae (1992) views the necessity for good communications in building and maintaining a strong strategic alliance relationship as follows:

“Both partners bring to an alliance a faith that they will be stronger together than they would be separately. Both believe that each has unique skills and functional abilities the other likes. And both have to work diligently over time to make the union successful.”

2.4. Communication in networks

Companies generally recognize that tight interaction and coordination among all the participants of their supply chain is a key requirement for their continued survival (Azevedo and Sousa, 2000). Supply chain coordination, according to D’Amours et al. (1999), is to become even more strategically important as new organizational forms evolve; some examples include virtual enterprizes, global manufacturing, logistic networks and different company-to-company alliances. In these cases, integration must run from one end of the business chain to the other—from a company’s suppliers through to its customers (Somers and Nelson, 2003). Furthermore, Somers and Nelson argue that in order to achieve the benefits of enterprize systems, it is important to develop a proper “fit” between the technology and the organization’s strategy and implementation choices. Integrated firms use IT to create new products and services, to alter linkages with suppliers and customers, to establish new standards of performance in their industries, and to have the ability to deliver consolidated information to customers (Johnson and Carrico, 1988). Browne and
Zhang (1999) conclude that the success of the extended enterprise, such as a strategic alliance, depends on intensive information sharing, with the result of a greatly reduced time-to-market through quick-response manufacturing, and with integrated and coordinated product design and manufacturing from all the participants.

In relation to the theory discussed above, a product realization process should deliver a complete product to the end customer, as well as have a structured way of handling feedback from the end customer back to the concept phase for the next product. Fig. 2 describes the information system view and the conventional material view as Clark and Fujimoto (1991) define them. These two views do not consider the need for an iterative way of working between different actors, but they do point out the necessity of a feedback loop in the system. In strategic alliances or other types of networks, this kind of information feedback loop needs to be developed in a consensual way.

Whenever both the customer and supplier will share in the profits, information sharing relies strongly on the trust between the partners (Berry et al., 1997). Kulmala et al. (2002) note that different kinds of profit-sharing agreements between partners increase the need for reliable cost information. These authors continue that in order for these companies to achieve a win–win relationship, suppliers should be able to calculate how much cost savings higher volumes will create.

2.5. CMMN practical example: the case of mass customization

According to Meixell and Wu (2004), collaboration is commonly achieved by one of two means, the first being the exchange of data and information, and the second through the concurrent development of plans for both products and production. Supply chains, they continue, are generally viewed as consisting of product, information and monetary flows, with this second step focusing on “joint planning to integrate flows not only within a company, but also across organizational boundaries”. One production strategy that entails numerous challenges in terms of increased information and material flows—especially when considering the complex coordination requirements for CMMNs—is that of mass customization.

Simply put mass customization refers to the customized production of goods or services—and increasingly product and service “bundles”—at or near mass production efficiencies (Pine, 1993). In the realm of collaborative manufacturing alliances, McClellan

![Diagram](Image)
lists mass customization as a market force of increasing importance, and a strategy that will require manufacturers to implement production systems that support agility and respond to small lot sizes and individualized customer requirements. The Society of Manufacturing Engineers has also listed mass customization and savvy customers, along with the use of collaboration for competitive positioning, as 21st century manufacturing macro-trends (Christman, 2003). Meixell and Wu (2004) also mention mass customization in the context of manufacturing networks, emphasizing the importance of collaborating in the supply chain in the difficult context of high product variety when products are mass customized.

The realization of mass customization often lies in the application of various methods, to include product rationalization, part and process standardization, component commonality, modular design, agile platform design, lean production and postponed manufacturing. There are a number of emerging information-oriented technologies that also play a strong enabling role in mass customization. Perhaps the most recognizable is the product configurator, its use revolutionized by Dell Computers (Magenta, 1998) and defined by Bourke et al. (1998) as “software modules with logic capabilities to create, maintain, and use electronic product models that allow complete definition of all possible product option and variation combinations, with a minimum of data entry and maintenance”. For large collaborative networks, technologies allowing information sharing in real time, synchronized inventory across the value-chain network, collaborative product design, and general information sharing are also essential (McClellan, 2003). In fact, many of the new Product Lifecycle Management (PLM) systems from major software vendors are now touting their ability to provide solutions for mass-customized production in large collaborative manufacturing networks.

3. The case study

In this section, the case study and its methodology are described, and the collaborative manufacturing mega-network (CMMN), along with its product, is introduced.

3.1. Methodology

The case study described in this paper was conducted during the spring of 2003 at the Saab Aerospace manufacturing facility in Linköping, Sweden. The case study method was chosen due to the qualitative and exploratory nature of the investigation at the company. Data was collected through semi-structured interviews of two Saab Aerospace managers. The interviews which were recorded were transcribed and subsequently approved by the respondents following feedback.

Prior to the interviews, the respondents were provided with the following research questions to consider for the analysis of an existing collaborative manufacturing network from three different perspectives:

(1) What is the design (structure) and organization of the network?
(2) How does the network coordinate and plan for resources, material and competence?
(3) How do companies in the network relate to external partners such as suppliers, final customers and other units?

The issue of product customization was also presented as an area of interest for the researchers.

3.2. Company and product profile

3.2.1. Saab Aerospace and the Commercial Programs business unit

Saab Aerospace was chosen as a case study example because of its important role in one of the world’s largest consortiums, that which has recently come together to develop Airbus Industries’ new “mega-jumbo” jet, the A-380. Saab Aerospace’s experience in this industry, however, is extensive, spanning 65 years of business, with more than 4000 aircrafts representing 15 different types, and serving more than 500 regional airliners, having left the company’s hangars in Linköping, Sweden (Saab Website, 2003). Given its role in the A-380 consortium and wealth of experience, Saab Aerospace was deemed by the authors as an important case that could help to illuminate the inner workings of a large collaborative manufacturing network.

More specifically, Saab Aerospace’s Commercial Programs business unit (“Saab”) was the contact organization for this study. Saab has a long tradition of international cooperation with a number of different companies, including the world’s two largest aircraft manufacturers, Airbus Industrie and Boeing.

Saab is currently participating in several civil aircraft projects, with a stated vision of collaborating in the design and system integration phase of aircraft structures development, and subsequently assuming responsibility for production and aftermarket activities (Saab Website, 2003). In the concept phase of the A-380’s development, Saab has played an important role with its participation in several studies during the pre-development phase.

The project in fact is one of the largest investments ever made by the aerospace industry, and has led to extensive cooperation among various companies and industries throughout the world.

As a partner in this project, Saab has assumed the responsibility for the design and production of structural work packages for the aircraft’s wings.

3.2.2. Airbus Industrie and the A-380

With more than 4500 aircrafts ordered by international customers, Airbus is an undisputed world leader in the civil air transport marketplace (Airbus website, 2003). Airbus Industrie emerged during 1970s to become the strongest rival of Boeing, the world’s top commercial airplane builder. Since then, Airbus has had a series of successes with its A-300, A-310, A-320, and A-330/340 models. During 2000, Airbus Industrie formally announced the A-380 project. Upon its projected delivery in 2006, the A-380 will be the largest passenger aircraft in the civil market, completing the Airbus product range with a “mega-jumbo”. The company has great expectations for the market requirement for this size and class of aircraft, expecting the demand to exceed 1000 over the next 20 years (Airbus website, 2003). In addition to its configuration for air travel with a capacity
between 555 and 900 passengers, the A-380 will also be configured for cargo as a three-deck, 150 tonnes long-range freighter.

3.2.3. Saab and A-380 wing manufacture

Airbus Manufacturing manages the production of Airbus aircraft, which takes place at different sites in Europe. The A-380 manufacturing is a trans-national process structured around key manufacturing units, each of which is responsible for producing a complete section of the aircraft for delivery to the final assembly lines (Airbus website, 2003). Fully equipped aircraft sections are airlifted by the Airbus Super Transporter A300-600ST, which boasts the world’s most voluminous cargo hold to the final assembly lines in Toulouse, France. Saab’s role in the manufacture of the A-380 involves the manufacture of the front-leading wing beam, as shown in Fig. 3. Saab transports these wing beams for further assembly to one of Airbus’ two manufacturing units in the UK, located in Broughton.

Saab’s cooperation with Airbus represents a relatively new strategy for the company. In the past, the company exclusively developed and produced military aircraft, and thus depended heavily on governmental support. In its subsequent move towards more commercial markets, the company implemented a business segment responsible for developing, producing, and marketing propeller-driven commercial aircraft. Saab was
forced, however, to make yet another strategic shift in the late 1990s, as the market shifted dramatically from propeller-driven to jet-propelled aircraft. Fig. 4 clearly illustrates this shift from turboprop to turbofan-powered aircraft, which according to Smith (2003) was described by many as a “rush for jets” (Kingsley-Jones, 2001):

With jets, Saab reasoned that the investment for building a complete aircraft in the role of system integrator would be too risky for the company. Saab mapped the market in order to identify possible focus areas, and performed several investigations to determine which areas were the most suitable. Given Saab’s experience and competence in the development and manufacture of complete aircraft, the company was capable of performing a wide range of tasks. In the end, Saab chose to alter its focus and became a sub-system supplier, responsible for the development and manufacture of aircraft parts for larger system integrators, such as Airbus—a change of corporate strategy that represented a major transformation for the entire Saab organization.

4. Case results and analysis

In the following section, the answers to the questions posed in Section 3 are presented and analyzed, based on the theoretical foundations laid in Section 2.

4.1. Application of network strategies

Saab’s strategic choice of assuming the role of sub-system supplier for system integrators compelled the company to participate in various collaborative manufacturing networks. In order to minimize the risks and at the same time reap the benefits of future profits, Saab negotiated with other companies within the Airbus Consortium and joined its strategic alliance. As discussed in Section 2.1, some of the benefits Saab could gain with a strategic alliance included sharing risk, exchanging resources, accessing new markets, and achieving economies of scale through increasing production volumes for its sub-systems. In the case of this strategic alliance, work is broken down into a structure of parts or sub-
systems, which in turn are combined together into easily manageable units for the different partners. The sub-systems are structured by functionality and/or complexity in order to support the management of final assembly and maintenance.

It is important to note that commercial aircraft, such as the A-380, consist of a number of separate functions that are integrated throughout their structure (see Fig. 5). For example, the hydraulic system is integrated throughout the A-380’s many sub-system structures, necessitating the need for extensive coordination among the suppliers of each structure/function. To support this integration, decisions are managed through a formal information and decision network supporting the integrated functional systems, such as the hydraulic system. This demands a great deal of coordination in the areas of information and knowledge sharing, with a clear structure for decision paths. Furthermore, the decision network requires supporting tools and superior organization in order to achieve the required results: high quality, at the right time, with the required functionality, and with traceability for future maintenance.

In reference to Fig. 5 above and as mentioned earlier, Saab’s role concerns the partial manufacture of a important A-380 structural sub-system—the wing, which must be coordinated with a number of functional sub-systems. Wing manufacture can be described with its own supplier network strategy and structure, as illustrated in Fig. 6:

Wing system manufacture begins with the wing beam structure, which is sent to Saab in Linköping, Sweden, by the French Mechachrome in Amboise. As discussed in Section 3.2, Saab’s role is the manufacture of the front leading edge structure for the wing. Once Saab has manufactured this wing structure, it is transported to the Airbus manufacturing facility in Broughton, England, for final integration into a complete wing system (see also Whitehouse, 2003). Finally, the fully-assembled wing systems are trasported to Airbus facilities in Tolouse, France, where they are integrated into the complete airplane system—the A-380.
4.2. Network structure in the case

The manufacture of today’s aircraft is achieved through the cooperation of enormous and complex manufacturing networks, involving numerous companies from numerous countries and even continents. As shown in Fig. 7, Airbus Industrial Consortium (AIC) has two main owners: British Aerospace (BAE) and The European Aeronautic Defense and Space Company (EADS). AIC in turn owns its own branches in France (F), Germany (D), Spain (Esp) and the United Kingdom (GB).

Each AIC branch is responsible for different sub-assemblies and/or final assembly of the complete aircraft. The next sub-level in this integration (not shown) consists of sub-system suppliers responsible for developing and manufacturing subsystems for the aircraft, such as the wing structure described in this case. This relationship of companies is illustrated in Fig. 8, with percentages indicating the estimated profit margins for companies in each hierarchical order. In effect, the higher a company climbs in the pyramid, the greater the risk for that company in the overall project. In today’s commercial aerospace manufacturing industry, only the largest organizations can afford the risk associated with the top position of the pyramid.
As described in Section 3.2, Saab’s strategy for its participation in collaborative manufacturing networks has been to step down from its previous role as “systems integrator” to that of “supplier of sub-systems”. In its earlier role as systems integrator, Saab was vertically integrated with its suppliers and end customers. In relation to the theory presented in Section 2.2, Saab has shifted from a vertically integrated structure where it performed nearly every aspect of the product realization process, including manufacturing, internally to one of horizontal integration. For Saab, horizontal integration implies that the company is now but one of several suppliers responsible for developing and/or manufacturing sub-systems or components for a product that is ultimately assembled by Airbus. This strategic shift from vertical to horizontal integration, with other companies responsible for different sub-systems in the final product provides Saab with nearly the same profit margin (see Fig. 8), yet with a much lower degree of risk.

4.3. Cultural issues and knowledge sharing in the case

According to Section 2.3, there is a need for companies collaborating in manufacturing networks to develop a trust-based relationship in order to develop, produce and deliver complex products. Achieving this level of collaboration, of course, requires time and commitment. In the case of Saab, the company has been integrated into the Airbus consortium as a partner with the responsibility for a sub-system of the wing, the wing structure. Thus, Saab’s traditional role as a company responsible for developing and manufacturing a complete aircraft has shifted to the role of one participant among many in a large strategic alliance.

During this integration, Saab sources estimated that up to half of all problems or misunderstandings had some sort of cultural link. Not surprisingly, attitudes towards other organizations and people were considered of extreme importance. For the most part, problems were connected to preconceived ideas about behavioral norms for different
countries. One obvious difficulty was the difference in the level of organizational hierarchy in each country. In Sweden, for example, it is common for managers to delegate decision-making for specific technology solutions to the resident expert in the company. Sending such an expert to a decision-making meeting in the United Kingdom, however, could be a potential cause for problems in the early phases of collaboration, since decisions there are usually made among managers at the same hierarchical level. As the project progressed, instances of culturally related misunderstandings decreased, as the collaborating partners became familiar with each other’s cultural uniqueness and routines. The experiences in the case show that a spirit of cultural understanding in the beginning of the collaboration is the most important factor that can reconcile the cultural difficulties.

4.4. Communication in the network

In the case, there was shown to be a strong need for exchanging product data relevant for each partner in its work to develop and manufacture components and sub-systems. The case also showed the importance of managing all product data collaboratively in order to support the final assembly of the aircraft, a requirement that was fulfilled through the use of an extensive specification manual and structured decision paths. Product data in the project was usually exchanged on paper through courier or regular mail channels with a fax backup, although electronic media and tape were also used. The three different media for exchanging data were used in different combinations and preferences, depending on the collaborative partners involved. For example, while Electronic Data Interchange (EDI) on single lines was occasionally used between some companies, some competence areas, such as purchasing and marketing, resisted its use as the users felt a loss of control in the exchange of information.

4.5. Customization issues

According to Bugos (2001), mass customization in the aerospace industry began in earnest with the introduction of the Boeing 747, a jumbo jet with 360 seats, which took international air travel to a new level when introduced in January 1970. Soon after, each nation had at least one airline, and each airline had slightly different requirements for the aircraft they used, with Boeing, McDonnell Douglas, and Airbus Industries pioneering new methods of mass customization to build aircraft to these specifications. Boeing Commercial Airplanes, for example, has demonstrated several “breakthrough approaches” for the implementation of a mass customization manufacturing system for its wing production (Qiao et al., 2003).

Saab Aerospace also boasts a culture of providing customized solutions, seeking to provide “customized technology at your service” through the offering of “state-of-the-art capabilities and resources that make Saab Commercial Programs the premium aerospace partner for the future” (Saab Website, 2003). While a customization mindset exists at the company, however, customization was not particularly applicable to the A-380 wing structures it manufactured. Thus far, these structures have been manufactured in two primary variants, one for a passenger aircraft and the other for a cargo configuration. There are, however, plans for at least six variants in total. With Saab’s focus on the proactive
development of its wing structures and a flexible production system, it is hoped that redesign and recalculation for meeting future demands can be reduced. In the future, an increased capacity to customize may be desirable for Saab, given its new role as system supplier.

Mass customization of the final system, or in other words the complete A-380, could be aided through the application of new developments in information technology, enabling knowledge sharing and facilitating communication across the entire CMMN. For the A-380, Airbus industries is currently deploying such a system in the form of an extensive PLM database system from a major vendor. The system will be used by more than 5000 engineers managing about 120 Terabytes of information, including 15,000 definition phase drawings, 3000 CAD workstation drawings, 150,000 parts in different configurations, and data from a global supply chain. According to Airbus, the system will make the management of the plane’s product structure, changes the release process, 2D and 3D visualization, connectivity to legacy systems and ERP easier, with the vision of applying the system across the partners and to the supply chain (AWST, 1998).

5. Summary of important factors for the successful CMMN

This section highlights some important factors for the successful CMMN, as identified in the case described in this paper.

5.1. Companies in CMMNs should be prepared for and open-minded to different types of inter-organizational collaboration

The case describes a network structure involving a multitude of companies from numerous countries, all collaborating in an enormous project consisting of several huge collaborative sub-system projects. This type of complex network structure was defined earlier in this paper as a “collaborative manufacturing mega-network” (CMMN), not only to illustrate its enormous size, but also to illuminate the technical, organizational, functional, and cross-cultural complexities of such a network. The CMMN described in the case is also an example of the current emphasis on horizontal collaboration, i.e. integration both geographically and functionally, as discussed in Section 2.2. Furthermore, the case also exhibits a type of diagonal collaboration with different companies responsible for complementary technologies.

5.2. Strategic choices made by collaborative partners are influenced by early participation in the concept phase, unique technology competence, and the level of shared risk

Saab’s decision to join one of the world’s largest consortiums—that of the Airbus A-380 CMMN described in this case—was based on an internal strategic evaluation of its future focus as well as from negotiations between Saab and Airbus regarding what contribution Saab could give to the consortium, and at what risk. Prior to making this strategic choice, however, Saab had played an important role in the concept phase of the A-380, providing it
with a wealth of knowledge and experience before the main project was initiated. This project-specific knowledge, coupled with its technical expertise, helped Saab to position itself in the CMMN as a wing structure sub-system supplier. In joining the CMMN, Saab became a part of a strategic alliance (see Section 2.1), implicitly and explicitly agreeing to share competencies and risk.

5.3. **Companies should see the trustful, win–win relationship that can arise with participation in a CMMN through the strategic utilization of each partners’ competencies**

The relational and performance risk characteristics found in an alliance, as mentioned in Sections 2.1 and 2.3, makes it crucial for participants to trust one another and evaluate what information different partners should have during the project, and when. For example, in order to foster a win–win relationship in a CMMN, partners must decide what kind of cost or technically-related information should be shared bilaterally with cooperating firms, and what part of the information flow should be multilaterally open to all participants in the alliance. This demands, however, that all partners have a sound understanding of their costs and/or technological uniqueness. For Saab, its shift from military aircraft manufacture with governmental support to commercial aircraft manufacture helped the company to become more market-driven and rational in its work. This has influenced Saab’s mindset regarding where the costs are in the product realization process, which includes all phases from concept generation to manufacturing and distribution. Today, Saab is responsible for the design and manufacture of structural work packages in the wing. However, the history of Saab as an aircraft manufacturer with total responsibility for a complete aircraft,—including maintenance, customer relationships and customization,—implies that Saab has both the competence and experience for an even greater level of responsibility in the CMMN. This latent capability potential can be viewed as an untapped asset, and one that could be further evaluated in future strategic discussions within the CMMN.

5.4. **Communications systems are strong tools that support work processes and mutual decision-making, provided that employees are trained in using these communication systems in the most suitable way**

Collaboration between several companies demands extensive communication in different ways. Working with product development and production generates an abundance of product data information during the iterative development process, information that must be reviewed, exchanged and traceable. Some users in the CMMN, such as development and manufacturing engineers, were more comfortable with the use of electronic data interchange (EDI) systems than other users, such as those in purchasing and marketing. In a CMMN such as this, it is important to find a reliable and efficient manner of communicating in order to decrease the time-to-market, a goal which could be at risk when the wrong version of a drawing or product data information is forwarded. Analyzing the respondents’ answers in the interview indicates that the product data exchange system could be either further developed or the users better trained in its functions.
5.5. **CMMN participants should receive cultural awareness training from the start to avoid potential problems during latter stages of the project**

To join a CMMN with a new strategy—that of becoming a leading supplier of a wing structures instead of a manufacturer of complete aircraft—obviously means massive change for an organization’s employees. In the case of Saab, changes required included the ability to relinquish great degree of control, moving from the management of a complete aircraft to that of a subassembly. During this period of change, it became apparent to Saab that cultural awareness issues between different countries and organizations had the potential for adversely affecting communication between partners, leading to potential delays. While cultural awareness issues did not present any major problems in this CMMN, it is the view here that the advance training in cultural diversity issues could be a positive and well-invested step in avoiding potential difficulties in such multi-cultural environments.

5.6. **For the CMMN system provider, the ability to plan for future products can be an important factor for future viability**

For Saab, its preparation for future opportunities, given its new role as a systems provider vs. systems integrator, may be more significant than its current cooperation in the A-380 project. If competitors, such as Boeing, are any indication, the day that Saab must deliver increasingly customized units may not be far away. Systems providers such as Saab are under pressure to increase the efficiency and utilization of invested resources while making the best use of available time, competence and equipment. According to Meixell and Wu (2004), it is collaboration in the supply chain, such as that found in this CMMN, that can drive such benefits in flexibility, lead-time reduction, and cost reduction. “In a mass customization environment”, they continue, “these benefits are essential to achieving the dual objectives of low price and delivery promptness”. McClellan (2003) also notes that collaborative manufacturing takes the practice of business collaboration to the factory floor, sharing real-time information among internal and external supply-chain partners to gain a competitive edge. Applying these researcher’s conclusions to the CMMN in this case, Saab has the opportunity to further develop and improve its wing structure manufacturing, with the potential of becoming a leading supplier within this area to several product owners.

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**References**


