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Performing supply chain design in three-dimensional concurrent engineering: requirements and challenges

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Abstract. Designing the supply chain at the same time as developing new innovative products and efficient production processes holds the potential of being a source of competitiveness for a pressured manufacturing industry. This paper studies actors that influence the practices of three dimensional concurrent engineering (3DCE). Developing product, process and supply chain in parallel requires considerable cross-functional coordination and strong supplier involvement. A single case study of a large manufacturer of security products and systems was applied to explore current practices in an ongoing new product development (NPD) project. Five key challenges were found as barriers to performing supply chain design within this complex collaborative effort. Also, five requirements are suggested as enablers to organizations that aim for reaping the benefits of integrating supply chain design in their development process. By understanding the requirements and challenges of this process, the potential of 3DCE can be released and create value for practitioners in industry.

Keywords: three dimensional concurrent engineering, 3DCE, new product development, supplier involvement, supply chain design, case study.

1 Introduction

Norwegian manufacturing firms experience intensified global competition from companies located in low-cost countries. Instead of competing only on price, many companies focus on developing advanced product and services that provide a premium value to their customers and users. In order to stay on top of the innovation cycle, managing new product development (NPD) processes becomes critical [1, 2]. Concurrent engineering of both product and process have been one response in order to make sure that product is meeting the customer needs and at the same time enable design for manufacturing. Shorter product life cycles, together with increased demand heterogeneity and the creation of several niche markets, are forcing many companies to respond faster, provide higher degree of customization and reduce their time-to-market [3]. Achieving this requires stronger collaboration with suppliers and partners in the supply chain. These developments imply the need to go beyond the scope of concurrent engineering which include product and process design. Fine [4] named this

expansion *three-dimensional concurrent engineering* (3DCE) and defined it as "...the simultaneous development of product, process and supply chain" (Figure 1).

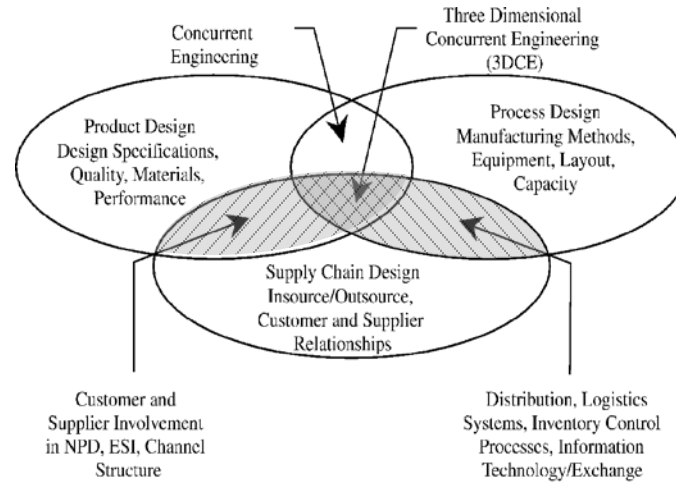


Figure 1: Scope of paper within 3DCE.

Source: Ellram et al., 2007[5], modified from Fine, 1998, p. 146 [4].

Despite a significantly growing interest in 3DCE, there is limited empirical evidence on current practices and experiences. While conceptual benefits and opportunities are well described [4-6], few researchers have addressed issues with such approaches, especially from a supply chain practices perspective. Ellram et al. [5] argue that while the answers to these procedural issues are fairly straightforward and common sense, it is their execution that creates a challenge. Similarly, van Hoek and Chapman [7] call for research that study the early efforts to leverage supply chain capability as part of the product development team in practice. Hence, the purpose of this paper is to present empirical findings from an on-going NPD project utilizing the ideas of 3DCE. The objective is to understand requirements and challenges related to performing 3DCE in practice. The study starts with an assessment of existing literature on the topic, and then uses empirical data from an on-going case to verify, modify and expand these factors in a summarizing framework.

2 Requirements and challenges addressed in literature

Concurrent engineering calls for significant cross-functional coordination. Adding the dimension of supply chain design in a 3DCE approach strengthens the need for external collaboration through supplier involvement. In the following section, requirements and challenges of 3DC will be presented, focusing on the intersections between product-supply and process-supply areas.

Early consideration of the supply chain perspective in the product development process is critical [6, 8]. van Hoek and Chapman [8] argue that the need for NPD and

supply chain to align is only increasing, and that supply chain management should be included from the beginning with the same level of authority as product and process development. Supply chain management should no longer need to clean up after NPD. Ellram et al. [5] argue that top management support and involvement of functional leadership would likely be necessary in order to orchestrate such coordination. Issues that need to be addressed in parallel are: efficient flow of new products, ramp-up of supply chain activities such as sourcing, manufacturing and distribution, as well as other related activities supporting the commercialization of the product [6]. Van Hoek and Chapman [7] have developed a model showing this evolution from a situation where alignment is limited to the final stages of NPD, to a situation where new products are seen as a joint mission for supply chain and product development (Figure 2). Consequently the focus shifts from product availability, further through increased coordination and efficiency, and finally a focus at leveraging the supply chain capabilities to help drive revenue and market impact.

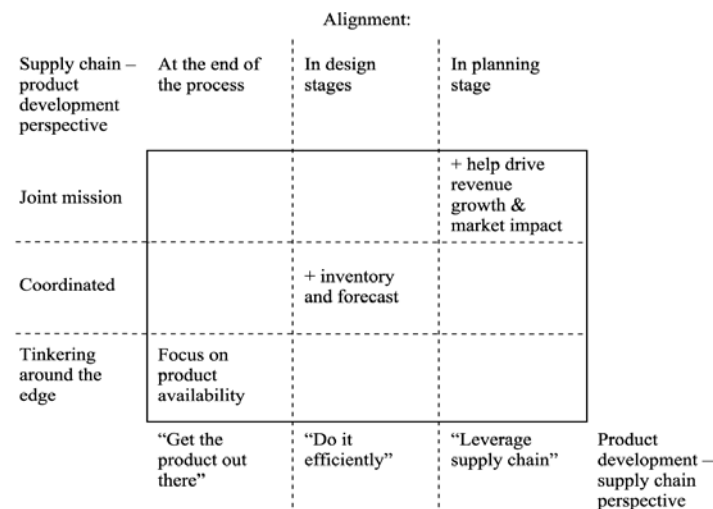


Figure 2: Aligning product development and supply chain [7].

Achieving early supplier involvement (ESI) can provide benefits of improved product quality, increased manufacturability, reduced time-to-market and development costs and decreased product cost [9]. Further, it also provide strategic benefits at the organizational level such as learning effects, access to new capabilities and insights into future directions for supplier product range [9]. On the other side, disadvantages and challenges are found to be risk of leaking important information and knowledge [10], risk of being stuck with wrong partner or technology [11], loss of bargaining power [9], and uncertainty related to suppliers competence and motivation [11]. To really leverage the opportunities created by supplier involvement, Christopher [12] highlights three important prerequisites: (1) a rationalized supplier base, (2) a high level of shared information and (3) the need for multiple, collaborative working relationships

across the organizations at all levels. A view that is supported by McIvor and Humphreys [13] as they pinpoint the need for high level of commitment and resource allocation from both the customer and supplier organization.

Table 1. Summary of factors affecting the integration of supply chain design in 3DCE

<i>Prerequisites for coordination and execution of 3DCE</i>	<i>Challenges with performing 3DCE</i>	Ellram et al., 2007	Cousins et al., 2008	Gadde & Shehota, 2000	von Corswant & Tunälv, 2002	Christopher, 2000	McIvor & Humphreys, 2004
Involvement of top management and functional leadership		x					
Rationalized supplier base						x	
Wide information sharing						x	
Resource allocation and collaboration on multiple levels						x	x
	Risk of information leaks			x			
	Stuck with wrong partner / technology				x		
	Loss of bargaining power		x				

3 Case study methodology

A case study approach is adopted to investigate challenges experienced in a company that is about to adopt a 3DCE process to improve their new product development practices. When the research is of an exploratory nature and the researchers investigate contemporary events, Yin [14] proposes a case study research method. The research was designed as a single case study in order to be able to understand the complex nature of the three-dimensional concurrent engineering in a NPD-project with a planned time line of about 24 months.

An instrumental case study provides insight into a particular issue, redraw generalizations, or build theory [15]. The purpose here is to provide insight into practical experiences with operating NPD project based on the principles of 3DCE.

As with most instrumental case studies, the research team wanted to provide insight into the issue of requirement and challenges of 3DCE by building on existing theory and comparing this with experiences from the field. Findings from the empirical investigation are compared with literature to bring further detail and structure to current issues.

Data is collected through workshops, interviews, and meetings with representatives of the case company. The data material currently contains transcripts from 9 interviews with managers from all involved departments in their development process and participation in 9 monthly meetings in a cross-functional development team. Document studied includes strategy documents, plans, organizational descriptions, policies and procedures and KPI data.

The case company is a large-sized manufacturer of safety and surveillance solutions with almost 400 employees globally and headquarters in Norway. They produce equipment and systems for securing assets and personnel used within multiple industries, such as construction, maritime, and oil and gas. They have a wide range of products within their portfolio. The case study on 3DCE is related to development of a new generation of one of their core high-volume products.

4 Results and discussion

4.1 Challenges with integrating supply chain design in 3DCE

The issue of *supplier involvement* created much debate in the case company. There were much discussions about whether to involve a supplier of the core material of the product directly into the development project team. And if so, which supplier should be selected? The company had a long standing relationship with supplier A, and had only recently started to purchase some parts from supplier B. Supplier A was initially suggested due their long common history. The purchasing department had recently identified that supplier B had more advanced production technology. Supplier B were perceived to be more flexible and willing to adapt, and was finally chosen in the team.

Even though supplier B had provided important knowledge on product materials and insights on manufacturability, there has been one identified challenge in this close supplier involvement. There is a tendency that the supplier is answering 'yes' to most questions on whether a specific feature or process will be possible for the new product. This inherent optimism might be explained by a fear of losing the long-term production contract in the next phase of the project. It might also be explained by the fact that the supplier's sales department has been the main contact point, and little collaboration has included other functions.

For the second core component in the product, a supplier was not invited to join the development project. The team feared a situation of "supplier lock-in", and wanted to have the opportunity to perform a price competition on the developed component between multiple potential suppliers, without having too strong ties with one single producer.

Within issues of *cross-functional coordination*, the decision making process was found to be challenging by the case company. Three-dimensional concurrent engineering inherently expands the numbers of objectives for the project: marked requirements on features, design for manufacturing and logistical requirements all impose a set of requirements for the end product. In many cases, these objectives are conflicting. In this case, the market wanted to have numerous product variants in order to manage pricing mechanisms across multiple industries, whereas the supply chain perspective calls for having fewer set of variants to keep in stock in many storage locations across the globe. Further, single decision variables were found to influence the solution space significantly on other product components. It is found challenging to design organizational routines and procedures that secure sufficient involvement of multiple stakeholders into these complex discussions.

Further, the project mandate was found to be an important factor for the coordination processes. The case data suggest that differentiated understanding of mandate and roles in the development process is a challenging factor. The case data also suggest that the role of top management is central and underutilized in the development process. Last, the lack of a specific supply chain role in the organization can lead to issues of sourcing, production and distribution is not as clearly represented in the discussions on central decisions for the product design. The project is organized under the technology/R&D unit of the organization, and operations departments are under-represented in the team.

4.2 Requirements for integrating supply chain design in 3DCE

The following factors were found in the case data to represent important prerequisites for integrating supply chain topics in the development process:

- Clarified key decision points in the process. The case company is applying a product road map following the stage-gate models, with 5 main decision points with their separate review boards. Production and supplier processes are described in the road map
- Core suppliers must be involved from early on. Their motivation might depend on their contractual situation with the core company, whether they are paid for their work in the development process, or they are secured a minimum volume of production in the operational phase.
- A clear mandate that is communicated to all parties
- Involvement of top management and all relevant functional units, with fixed meeting intervals. The company are using cross-functional teams to coordinate across functions, units and locations.

4.3 Framework

The findings of the case have made us able to propose a framework for requirements and challenges of integrating supply chain design in three-dimensional concurrent engineering (Table 2).

Table 2. Framework for performing supply chain design in 3DCE

Influencing factors:	<i>Require- ments (R)</i>	<i>Chall- enges (C)</i>	Found in literature	Supported in case
1. Involvement of top management and functional leadership	R		x	x
2. Rationalized supplier base	R		x	Incon- clusive
3. Wide information sharing	R		x	
4. Resource allocation and collaboration on multiple levels	R		x	
5. Clear mandate communicated to all	R			x
1. Risk of information leaks		C	x	
2. Fear of being stuck with wrong partner / technology		C	x	x
3. Loss of bargaining power		C	x	x
4. Unclear and complex decisions making process		C		x
5. Lack of supply chain role: voice of logistics in team		C		x

5 Conclusion

The framework in table 2 emphasizes five key requirements and challenges of achieving true integration of supply chain design in three-dimensional concurrent engineering. These five factors can serve as an important guideline with DOs and DON'Ts for managers and project managers in concurrent engineering projects.

For the case company, three specific advantages have been identified from applying the principles of 3DCE:

1. Selection of more proper components. Experiences from previous NPD projects within the case company show that components have been included in the product design, where the timeline for 'last-buy' from supplier had passed, making the availability of product components challenging and more costly.
2. Increased focus on product variants and customer-order decoupling point. A maturity level of understanding of the consequences of high number of product variants for supply chain control can be observed.
3. Selection of right suppliers as partners. Increased collaboration on supplier selection has given the company access to new capabilities and competence that it did not have available previously.

We call for further research on validation of the framework with more empirical data in a multiple case study in different industry sectors. Another interesting line of research will be to investigate how principles of three-dimensional concurrent engineering can be applied in small and medium-sized enterprises, where access to resources is lower.

Designing the supply chain at the same time as developing new products and efficient production processes holds the potential of being a source of competitiveness for a pressured manufacturing industry by contributing to reduced cost and time-to-market. The effect of working concurrently with products, process and supply chain needs to be examined further with additional empirical studies.

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