Functional Requirements for a Collaborative Order Management Tool for Use in an Engineering Setting

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Abstract. When products are engineered to order, meeting customers' expectations requires efficient order management. Despite its importance, literature on order management in the engineer-to-order production situation is scarce. This paper contributes to filling this gap by presenting functional requirements for a collaborative order management tool for use in an engineering setting. The functional requirements were derived from theory and validated and expanded through interviews with two case companies. Feedback from the case companies supports the usefulness and validity of the proposed requirements.

Keywords: Order management, engineer-to-order, collaborative tool, functional requirements

1 Introduction

In 1996, Lampel and Mintzberg [1] concluded on the basis of a comprehensive literature review that "we are in the midst of a fundamental technological change in manufacturing, communication, distribution and retailing – a virtual renaissance of customization" (p.28). Nearly a decade later Fredriksson and Gadde [2] found that more recent literature showed a continuance of the attention to customization, and argued that the increasing interest in customization could partly be explained by the fact that customers demand highly customized products and services, and partly by its marketing drive; it is claimed to improve the competitive position of the company.

A high degree of customization makes it increasingly difficult for an organization to collect, store and process the information describing customer orders [3]. This is the case when products are engineered to order; i.e. manufactured to meet a specific customer's needs by unique engineering or significant customization [4]. In this environment efficient order management is a prerequisite for meeting customers' expectations, and there is a need for information systems supporting the engineering organization throughout the whole order management process [5]. However, literature on order management in the engineer-to-order production situation is scarce and focuses mainly on production planning and control, due date setting and how tools developed for make-to-stock apply to order-driven production situations [6]. Little literature describing what kind of information is needed throughout different phases of the order management process, how it should be shared and by whom, has been identified.

adfa, p. 1, 2011.

This paper contributes to filling this gap by presenting functional requirements for a collaborative order management tool for use in this setting.

The remainder of the paper is structured as follows: First, the research method is described. This is followed by a literature review, where functional requirements for a collaborative order management tool are derived from theory. Thereafter, two case companies are briefly presented together with their requirements for collaborative order management. Their requirements are then matched with the requirements derived from theory. Finally, conclusions including limitations and opportunities for further research are presented.

2 Research Method

When the research is of an exploratory nature and the researchers investigate contemporary events while being unable to manipulate behavioral events, Yin [7] proposes a case study research method. One weakness of building theory from cases is that the researcher is not able to raise the level of generalizability of the theory [8]. In this respect, evidence from multiple cases is generally considered more compelling than a single case study [7]. With these characteristics prevailing, it was decided to conduct a multiple case study of two rather different companies within the EU FP7 project LinkedDesign (Linked Knowledge in Manufacturing, Engineering and Design) consortium; an offshore design and engineering company and an automation systems manufacturer (these are described further in chapter 4). A semi-structured, focused interview was conducted with each of the companies – aiming to validate, refine and expand a list of functional requirements for a collaborative order management tool that were derived from theory. The interviews were transcribed and data from each company was sorted in four categories: main focus of order management in the company; current situation; tools used; and future needs and challenges of the company. Thereafter, the information was compared to the requirements derived from theory; allowing validation and concretization of the requirements.

The differing characteristics of the case companies forced the researchers to come up with rather general functional requirements for a platform facilitating collaborative order management. Consequently, the results from the research should prove valuable beyond the context within which they were created.

3 Literature Review

In engineering projects, products are manufactured by means of unique engineering design or substantial customization based on orders specifying what to produce and when it should be finished. Order management involves creating and maintaining this information about product specifications and the promised delivery dates [9]. It can be divided into two phases: order acquisition and - fulfillment [3]. The latter is sometimes used interchangeably with the overall term order management [10, 11]; however, as the two phases have different challenges [9] the distinction between order acquisition and order fulfillment is adopted in this paper.

Order acquisition. In the order acquisition phase, the goal is to obtain an order whose terms are a consensus between the project organization and the customer, by eliciting customer needs and communicating available options [9]. In an engineering setting, this will typically happen through two succeeding stages: marketing and tendering. In the marketing stage, the decision of whether or not to respond to an invitation to tender is made based on customer requirements, commercial factors, the organization's ability to compete and the likelihood of success [12]. If the organization decides to respond to the invitation to tender, preliminary development of the conceptual design and definitions of major components and systems are conducted, including technical features, delivery terms, price and commercial terms [12].

Muntslag [13] makes a distinction between three types of order-dependent risks in engineer-to-order situations; *technical risk*, *time risk* and *financial risk*. Technical risk refers to the situation where a product cannot be technically produced, which necessarily leads to more product engineering and detailed design. Time risk is the risk of encountering a throughput time in engineering and manufacturing that is longer than what was estimated in the tendering stage, whereas financial risk is the risk of engineering and production being more costly than estimated in the tendering stage.

Order fulfillment. Given that the order acquisition phase led to the generation of a customer order, the purpose of the order fulfillment phase is filling, delivering and servicing what is ordered within the agreed delivery date [11]. Possible activities carried out in this phase are order entry, routing, assembly and picking, shipping, installation, invoicing and collection [10]. The risks associated with order acquisition are inherited to the order fulfillment phase, where inaccurate estimates of product specifications and delivery due date may become evident.

The main challenge in the order fulfillment phase is to cope with occurring modifications to product specifications and delivery dates [9]. Such *change orders* are a common feature for engineer-to-order companies [14], and the capability to respond to these short term dynamics is a prerequisite for success in many engineering organizations [5]. Change orders are not always a disadvantage for the project; they may as well result in additional income, cost savings or performance improvements [15]. Further, not all change orders are initiated by the customer. It may also be engineering changes proposed by designers that need to be communicated to e.g. sales/marketing, production planning and the customer [16].

Collaborative order management. Managers often view order management as part of a firm's logistics function [11]. However, order management activities cut across several functions within a company as well as other supply chain actors [17], necessitating integration between them [11].

Coordination in the order management process often lacks due to differing objectives of sales and manufacturing [16, 18-20]; sales/marketing wish to maximize their number of orders received, adapting quickly to shifting market demand and cutting quotation prices and delivery times. Manufacturing, however, prefer a stable and smooth workload over time, to cut product-, overhead- and inventory costs [18].

Overcoming this type of sub-optimization through increased collaboration between the functions is likely to result in more realistic lead times quoted to the customer [21] and fewer production planning problems [19] as order-dependent risks incurred are eliminated, or at least severely reduced.

Technology supporting collaborative order management. Technology generally enables a higher degree of integration between various actors in the supply chain. Order management is now supported by technology that facilitates supply chain visibility [22] and eases sharing of information [23], e.g. about production/delivery schedules and order status for tracking/tracing [24]. IT systems, such as product configurators, ERP- and PLM systems may help ensure technical feasibility by formalizing the rules about how products can be configured and providing user interfaces that helps sales/marketing with translating customer requests into technical specifications together with estimating costs and delivery dates [9].

According to Hicks et al. [12] effective sharing of information "requires use of common databases that support tendering, design, procurement, and project management. This requires records of previous designs, standard components and subsystems, together with costing, planning, vendor performance and souring information" (p.189). It should be noted that information sharing is merely an enabler of coordination and planning in the supply chain; companies will have to develop the right capabilities to effectively utilize the shared information [24].

Based on literature, we propose the following requirements for a collaborative order management tool for use in an engineering setting (**Table 1**):

Table 1. Requirements derived from literature

	Requirements:	Sources:
Totality	Should support both order acquisition and order fulfillment activities	[3, 9-12]
External	Should facilitate information flowing between the market and the organization	[9, 12]
Internal	Should facilitate information flowing rapidly within the organization	[11, 17, 19, 21]
Reliability	Should address and mitigate technical, time and financial risk	[13]
Transparency	Should enable sharing of current order and production statuses as well as plans and forecasts for partners involved on a real-time basis	[22-24]
Simplicity	Should ease order management and minimize administrative time	[9]
Conformance	Should align customer requirements, finished product and delivery date	[9]
Flexibility	Should facilitate rapid handling of change orders	[5, 9, 14-16]
Compatibility	Should be compatible with existing technology	[12]
Repository	Should store records of previous designs, standard components and subsystems, costing, planning, vendor performance and sourcing information	[12]

4 Case Descriptions

A) Offshore Design and Engineering. The company is a leading global oil services company that provides engineering services, technologies, and products for the oil and gas industry. The company employs approximately 18 000 people in about 30 countries. The Engineering business area delivers engineering, procurement and project management services to clients in the oil and gas industry. Three representatives from the engineering unit were interviewed regarding support for collaboration in the company's supply chain. Table 2 below summarizes Company A's input to requirements for the order management process in the company.

Table 2. Company A's requirements for collaborative order management

Order acquisition	• Support risk identification *(Reliability)* • Support resource sharing internally, especially during front-end studies *(Internal)* • Communication of good solutions; lessons learned and experience *(Repository)*
Order fulfillment	• Collaboration support across multiple time zones. *(Internal, Transparency)* • Communication with sub-contractors and fabrication units *(External)* • Supply chain visibility; see status from fabrication *(Transparency, Simplicity)* • Timely detection of errors, reasons and context and the actions taken *(Flexibility)* • Share lessons learned from previous projects; reuse smart solutions *(Simplicity, Repository)*

B) Automation System Manufacturer. The company is a global supplier of industrial automation systems and service. They deliver robots and automated production lines to several industrial sectors, including automotive, aerospace, steel, transportation and energy. The company serves as a system integrator and offers complete engineering solutions, from product development to manufacturing and maintenance. In this work representatives from the Powertrain Machining & Assembly business unit were interviewed. Table 3 below summarizes Company B's input to requirements for the order management process in the company.

Table 3. Company B's requirements for collaborative order management

Order acquisition	• Understanding of the cost of delivering what the customer wants *(Conformance)* • A way to easily propose multiple solutions in the same proposal *(Simplicity)* • A way to include life cycle cost data in the proposal *(Repository)*
Order fulfillment	• Role based functionality with easy access to most used systems *(Compatibility)* • Transforming customer needs to requirements and costs *(External, Conformance)* • Frequent change orders, both from external customers and process improvements identified internally *(External, Internal, Flexibility)* • Support passing around change orders in the project between technical personnel and project managers before approval *(Internal, Flexibility)* • Records of how previous problems were resolved *(Repository)* • Possibility to search within knowledge history *(Repository)*

5 Functional Requirements

The cases made validation of the requirements derived from literature possible, and helped refine several of them – for example by stating actors involved and what information should be shared. By combining this information, the following functional requirements for a collaborative order management tool are proposed (Table 4).

Table 4. Functional requirements for a collaborative order management tool

Requirement	Description	Found in cases
Totality	Should support both order acquisition (marketing and tendering) and order fulfillment activities (order entry, routing, assembly and picking, shipping, installation, invoicing and collection)	(A, B)
External	Should facilitate information flowing from the market (subcontractors, customers, partners) to the organization, and vice versa	(A, B)
Internal	Should facilitate information flowing rapidly within the organization, e.g. access to domain experts and available resources	(A, B)
Reliability	Should address and mitigate technical, time and financial risk	(A)
Transparency	Should enable sharing of plans and forecasts, current orders and production status in real-time and across multiple time zones	(A)
Simplicity	Should ease order management and minimize the time used on administrative matters, e.g. by easily proposing multiple solutions in the same proposal	(A, B)
Conformance	Should support conformance between customer requirements, finished product and delivery date	(B)
Flexibility	Should facilitate rapid handling of change orders	(A, B)
Compatibility	Should be compatible with existing technology	(B)
Repository	Should store and facilitate searching in records of previous designs and solutions, standard components and subsystems, costing, planning, vendor performance and sourcing information.	(A, B)

6 Conclusion

This paper has presented functional requirements for a collaborative order management tool for use in an engineering setting. These were structured along ten dimensions: totality; external; internal; reliability; transparency; simplicity; conformance; flexibility; compatibility; and repository.

Feedback from the case companies supports the usefulness and validity of the proposed functional requirements. Some limitations still need to be mentioned. First, we acknowledge that more empirical validation is needed in order to generalize our findings. Based on our requirements, we have developed a series of mock-ups describing a possible collaborative order management tool. Further research should include prototyping a tool for collaborative order management based on these mock-ups, and validating this against more companies. Second, we do not claim to have a complete list of requirements for order management in an engineering setting. Other companies may require other functionality than we have presented here. However, basing the work on two specific use cases has made it possible to come up with requirements and design that can be directly relevant for the industrial partners and companies with similar characteristics, increasing the probability of improving their collaborative order management processes.

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