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Professional MBA
Automotive Industry

Development of a sales and operations planning framework for the automotive engineering-to-order business using the example of body electronics

A Master's Thesis submitted for the degree of
"Master of Business Administration"

supervised by
Prof. Bernd Hellingrath

Dr. Maximilian Austerer

9825415

Vienna, October 17, 2016

Affidavit

I, **MAXIMILIAN AUSTERER**, hereby declare

1. that I am the sole author of the present Master's Thesis, "DEVELOPMENT OF A SALES AND OPERATIONS PLANNING FRAMEWORK FOR THE AUTOMOTIVE ENGINEERING-TO-ORDER BUSINESS USING THE EXAMPLE OF BODY ELECTRONICS
2. ", 72 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
3. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 17.10.2016

Signature

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Vienna, October 2016

Abstract

This work is analyzing the sales and operations planning process as described by the operations management body of literature with respect to the application in the automotive engineering-to-order business environment. There is still a research gap in the area of the application of sales and operations planning to the engineering-to-order business situation. In order to help closing this research gap a real-world industry case out of the automotive industry featuring an engineering-to-order situation is described as an example. Based on a reference model for a sales and operations planning process, changes to the process are proposed to adapt this framework to the specific engineering to order situation. The main adaption to the state-of-the-art is the inclusion of the engineering domain into the operations part of the sales and operations planning process. In literature the operations aspect of sales and operations planning is strongly focused on the manufacturing aspect of the value chain. Concrete ideas are being presented on how a sales and operations planning process that is aimed at improving overall business performance (measured by sales, profitability and cost targets) in an engineering-to-order business could look like. This work concludes with proposals to implement these ideas in the discussed industry case and mentions topics which should be addressed by further studies in this field.

Contents

1. Introduction

This thesis starts with a section on the motivation for this work, followed by an outline of the goal and the research questions that are subject of this work. The introductory chapter concludes with a description of the methodology used to answer the research questions and an overview about how this thesis is structured.

1.1. Motivation

One of the key business processes in any organization is the planning process. At the start of any project typically a plan is drawn up, how to achieve the project targets. In a competitive business environment one of the key success factors is the accuracy of plans. If the plans are not accurate or covering the wrong scope, people will not be able to "work the plan" typically leading to a competitive disadvantage because volumes and quality of products cannot be guaranteed any longer.

My professional experience as a group leader in the R&D management of an automotive Tier 1 supplier has triggered my interest to investigate if there are ways to improve planning quality in my work environment. One of the biggest challenges is the improvement of R&D planning and performance for our custom-development programs. In the product line I am working for, we are being confronted with a strongly growing multi-project business environment which clearly shows us the limitations of our current approach to short and mid-term planning of the R&D activities. Today's approach is more suitable for mature product lines where a solid forecast is available, deviations from the plans are only minor and also product technology has already stabilized.

The typical product lifecycle phases in the concerned business can be described as follows

1. Innovation phase
2. Platform development phase
3. Customer quotation phase
4. Product development phase
5. Mass production phase

Each product line has its own innovation programs. The innovation programs shall prepare new technology for the respective product line in order to be able to offer the customer a new product. The generic platform development phase shall build a foundation so that the customer specific product development can be shortened as much as possible. In the customer quotation phase the engineering and the order price of the products are quoted to the customer based on a customer engineering specification. In case of business award, the product is developed according to the specification and upon completion of the development phase, the product enters the mass production phase and the customer orders are fulfilled based on electronic call-offs.

This type of business can be referred to as an engineering-to-order (ETO) situation, since the majority of the value-add –namely product development- to the product is done specifically based on a customer order (Gosling & Naim, 2009). Other alternatives are more conventional approaches like built-to-order (BTO), or built-to-stock (BTS) situations in which the producer has already developed a generic product which then is produced, either after order received (BTO) or according to fixed plans (BTS).

Since I am especially concerned with the operational business, and there mainly with the product development phase, my personal interest and expertise is how the short to mid-term planning horizon can be optimized.

Strategic considerations and planning covering the span greater than 5 years are not in the focus of this work, except that the aim of our operations is eventually defined in the company strategy. In order to reach the goal of this strategy, tactical planning has to be applied in the different business processes (R. Ackoff, 1970). For me the tactical planning perspective is of the greatest importance. Currently the tactical planning in product development consists of rather disconnected individual plans, done by different engineering managers in different locations. There are yearly alignment meetings between the sales organization and the product lines, but without a stringent process and further tracking of the findings and agreements. One problem that arises as a consequence is a mismatch of engineering capacity demand and the available capacity. It is obvious that there is room for improvement in this process which will lead to an improved competitiveness market for the company in the respective product field.

One way to perform tactical planning is Sales & Operations Planning (S&OP). Sales & Operations Planning is a tactical (i.e. short term) planning process that integrates and then improves different plans to optimize the balance between supply and demand in order to contribute to achieving the company strategic goals (Grimson & Pyke, 2007). The method of S&OP has many aspects that match the challenges that we are facing:

1. Integrating the partly existing different (product line and sales) plans
2. Improving the planning
3. Balancing supply and demand. In this particular case referring to "supply" and demand of engineering capacity, which is in the ETO situation directly linked to the customer demand.

Generally there is less operations management (OM) literature on the special needs of ETO production systems, than on the more conventional high-volume make-to-stock production systems (Gosling & Naim, 2009; Hicks, McGovern, & Earl, 2000). However it is expected that increasing customization which is a key property of the ETO situation will become more important in the future, since it allows differentiation from competitors and thus can provide an competitive advantage (Gosling & Naim, 2009). Carvalho, Oliveira, and Scavarda (2015) summarize in their paper that there is a research gap between practice and literature when it comes to ETO specific aggregate production planning. This paper aims to help closing the gap that exists in the context of OM and ETO. Firstly, it refers to a real-world ETO industry case, thus it is close to practice and secondly it addresses S&OP. In scientific literature there is only very little material on the combination of an ETO situation with the application of Sales & Operations Planning. Close to this topic is a paper by Carvalho et al. (2015) which presents research on a tactical capacity planning problem in the ETO context. However, the paper is focused strongly on developing a linear programming model to optimize the capacity planning in a particular real-world industry case. This work has been continued by the same authors (Carvalho, Oliveira, & Scavarda, 2016) extending the scope by including the element of uncertainty into the equation. The analysis in this paper shall also include the element of uncertainty and aims to analyze how S&OP can be utilized to manage the inherent uncertainty of ETO.

1.2. Goal of the thesis

This thesis shall contribute to close the research gap in the area of ETO and S&OP. Considering the background automotive Tier 1 industry case two main research questions shall be answered by this thesis:

1. Which aspects of the existing Sales & Operations Planning practice can be applied effectively to an automotive Tier 1 engineering-to-order industry case?

2. How can Sales and Operations Planning help to improve the business performance considering mainly the planning and development phases of such an engineering-to-order program?

Ultimately it is the goal of this work to come up with new ways of improving business performance in the automotive ETO industry by applying S&OP practices. Practitioners should be able to use these insights to set concrete actions in their respective business environments.

1.3. Methodology

This thesis is basically utilizing a simplified case research approach to answer the above research questions. The author is part of the management team of a global automotive industry company and has nearly 10 years of professional experience in the fields of engineering and the acquisition and sales process. The main input to the research work is the observation of the business development of a selected product line of that company during the last 10 years.

As described by Voss, Tsikriktsis, and Frohlich (2002) in their paper on case research in operations management, the strengths of case research are that the phenomenon (in our case application of S&OP or the lack of it in the observed ETO case) can be studied in the natural real world context and that it is particularly well suited for investigations of new phenomena (as can be seen from the fact that there is only little literature describing this particular research case.) They also highlight the typically high value for the practitioner that case research is providing. This aspect is of special importance for this work, since it is planned that the results of the research should at least partly be implemented in the respective company.

The fact that only a single case is analyzed brings some limitations with it. Generalizing the results needs to be done carefully because for example it cannot be excluded that other automotive ETO companies have the same business processes but leading to different results. Due to the fact that there is only little literature describing the combination of ETO and S&OP the risk is rather low that there are a lot of applications of S&OP in this business situation leading to totally different results, but looking at a single company case is surely a limitation to the validity of the results.

The research questions are being answered by comparing the case observations (i.e. business process, organizational structure and the business results) with the S&OP process from the operations management body of literature. S&OP structures, best practices are analyzed and matched with the case observations where applicable

The basic starting point for matching state-of-the-art S&OP concepts with the specific ETO situation will be the S&OP framework developed by Thomé, Scavarda, Fernandez, and Scavarda (2012). This framework describes basically the context, inputs, structure and processes and outputs of S&OP as it is being described in the body of literature. One example how this framework has been applied to an industry case is shown in the paper by Ivert et al. (2015).

As a second step it will be checked which elements of the framework are applicable for ETO scenarios and the existing gaps will be identified in order to come up with ideas for their closure.

In the step thereafter the automotive Tier 1 ETO industry case will be characterized, the relevant business processes identified and the framework with its ETO relevant gaps will be evaluated accordingly.

Finally, the Thomé et al. (2012) and Ivert et al. (2015) approaches will be applied to the industry case, a resulting modified S&OP framework will be developed and discussed with respect to the research questions.

1.4. Structure of the thesis

The remainder of this thesis is structured as follows. Chapter 2 describes the theoretical background of tactical planning, S&OP and the consolidated state-of-the-art S&OP framework model, followed by explaining the specifics of ETO. A section on the gaps and the applicability of ETO in the current S&OP framework follows. Chapter 2 concludes with introducing the paper of Ivert et al. (2015) and its relevance for this work since it is an example of a concrete application of the S&OP framework to an (food) industry case. In chapter 3 the concrete industry case is described in more detail describing its specific challenges and processes. Chapter 4 finally brings together chapter 2 and chapter 3 and analyses the industry case with respect to S&OP and describes how to extend the S&OP model with ETO. In chapter 5 the results of the analysis are discussed and chapter 6 concludes the thesis with a summary and gives an outlook for potential further research.

2. Theoretical Framework

In the following chapter the theoretical background as it can be found in literature that is relevant for this work will be discussed. In the first two sections the definitions and findings relevant for the areas of tactical planning and sales and operations planning are being reviewed. In the third section the S&OP framework that has been developed by Thomé et al. (2012) is described in detail. In section four the engineering-to-order business and the connection to S&OP are being explained, followed by showing the gaps that are still found in the current state-of-the-art in chapter four. The chapter concludes with a description of the work by Ivert et al. (2015) which is representing the closest research that can been found with respect to the topic of this thesis. This chapter together with the next chapter that is describing the underlying industry case shall serve as the basis for the results and discussions part of this work.

2.1. Tactical planning

Generally speaking there are three planning levels in every business organization(R. L. Ackoff, 1974):

- Strategic planning
- Tactical planning
- Operational planning

Strategic planning is related to achieving goals on a company or business unit level. Examples could be becoming world market leader in a specific product segment with the goal to have unrivalled market power, or achieving a globally balanced sales structure to be more robust against regional economic down turns, or working towards forward or backward integration in the value chain, in order to increase the value add of the company's products or services.

Tactical planning is comprised of all the intermediate steps between the strategic level and the operational level. It is its goal to break down the strategic objectives to the different functional organizations and provide measures to contribute to the superior strategic goal. For example, a tactical planning aspect could be to identify the markets in which the company is not market leader and then develop respective market specific strategies to become number one. In the case of globally balanced sales, the tactical level could be to generate a specific KPI for regional sales and set incentives and targets accordingly. If the strategic goal is to increase the value-add portion in the company's portfolio, then the tactical steps could be to identify the most suitable product lines, look for M&A or JV targets that could help in doing so. These are just some examples of the scope of tactical planning in a typical company, where it already becomes obvious that on the tactical level there is a strong cross-functional element, which is not so much present on the strategic and operational levels.

Operational planning is dealing with the execution of the plans laid out in the tactical planning process. It involves tasks that are typically found on the lower management levels such as team lead or project manager: The planning of concrete tasks such as getting the market intelligence research done in time, installing a new sales office in a new market, conducting a business case calculation for the forward integration of product's A value chain, or ordering the right amount of supplies, doing the right production scheduling or planning the phases of a new product introduction.

Sales and Operations Planning is one of the practices in the tactical planning domain. Its purpose is it to develop tactical plans to achieve a competitive advantage over the competition(Cox & Blackstone, 2004) This is basically achieved by balancing supply and demand and by aligning different functional plans in a business organization to optimize the business result.(Grimson & Pyke, 2007).

2.2. Sales and Operations Planning

S&OP is a business practice to improve the vertical and horizontal alignment in strategic management (Fig. 1) (Ghobadian et al., 2007). Vertical alignment means that it helps to transform a corporate strategy in a firm into operational plans on the "shop floor". Horizontal alignment means that it utilizes information from all (or most) of the different functions that are available on the tactical level in a firm, such as the operations, the sales, the product development and other departments.

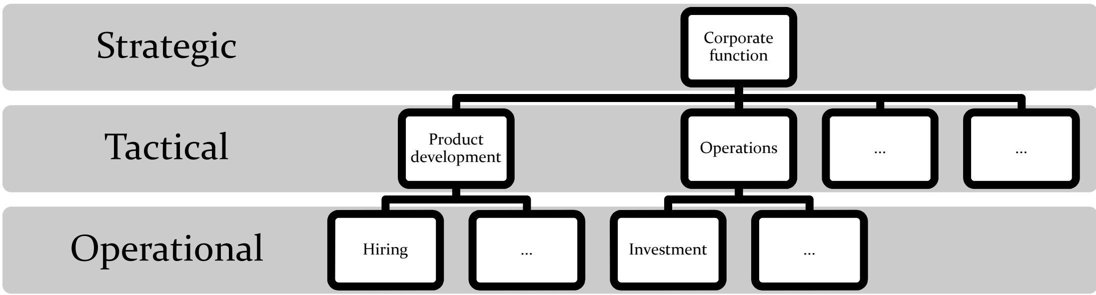

Fig. 1 Vertical and horizontal relationship in strategic management

Although definitions of the term S&OP differ in literature, the common aspects that can be found are the following (Feng, D'Amours, & Beauregard, 2008; Grimson & Pyke, 2007):

- Cross-functional and integrated across the functions planning
- Planning horizon with a maximum of 18 months
- Links strategy to operations
- Creates value and increases performance of the company

Another definition emphasizes the dimension of working towards a single operating plan and supporting decision-makers:

“Sales and Operations Planning (S&OP) is a set of planning and decision-making processes that not only balance product supply and demand but also link day-to-day operations with business goals, operational planning and financial planning.

The objective of S&OP is to enable decision-makers to reach consensus on a single operating plan that allocates critical resources purposefully to reach corporate performance targets” (Ventana Research, 2006 : 5)

The most important findings in Snow’s study were that global competition and rising customer expectations are the top drivers to improve S&OP, that a global organization as it for example can be found typically also in automotive Tier 1 mega-suppliers makes it harder to achieve good S&OP and that S&OP is still not deployed widely in the industry and if it is deployed, that the objectives of S&OP are not fully clear to the management. Another important insight shows that companies with shorter reporting frequencies (e.g. monthly vs. quarterly) show greater gains, as well as for companies that have longer planning periods (e.g. 18 months vs. 6 months)

Since the definition for and the implementation of S&OP in a company is not straight-forward, breaking down the gradual implementation of S&OP into several steps helps to get the process started and to be able to measure the degree of implementation. One way of showing the implementation maturity is shown by (Cecere, Barett, & Mooraj, 2009):

Fig. 2 Four steps for implementation of S&OP

They are describing the implementation of S&OP as a “journey” starting from a simple operational plan (e.g. work plan for tonight’s shift on the shop floor). The next stages involve actually matching supply and demand as a goal, involving already more the sales and marketing community that provide the forecasts. The balance is then shifting more towards the sales side, from where more detailed forecast and market intelligence data comes, that finally even enables demand shaping, which is achieved when both sales and operations have equal or balanced say in the process.

A depiction of the relevant input factors to S&OP can be seen in the below figure(Cecere, Barett, et al., 2009):

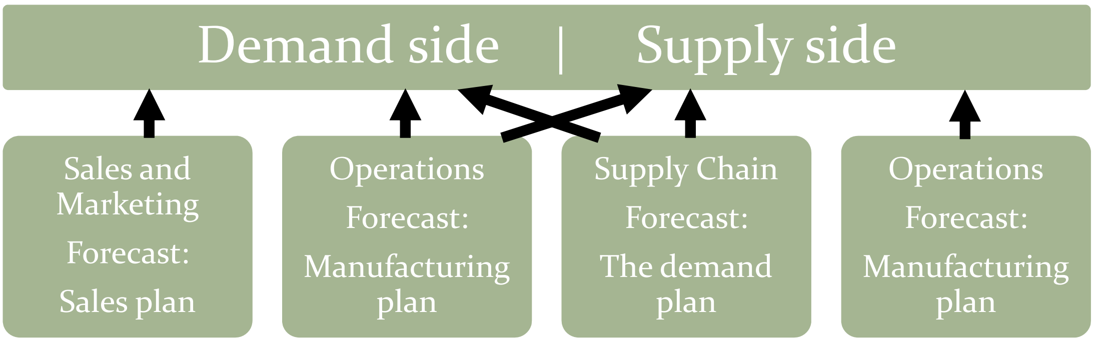

Fig. 3 Relationship of different functions to the supply and demand sides

The important finding they made is that in decision processes to achieve clear demand plans, both the supply and demand views are key. A pure supply-view would mean that the organization is for example only focusing on optimizing their manufacturing footprint to for example low-wage countries.

The researchers also identified that S&OP teams that had shared targets and metrics were more successful than those without. In particular targets such as forecast accuracy, perfect orders, revenue, profitability and inventory have been identified. Another important sign for high S&OP maturity was the link between sales and operations planning to strategic procurement, once again linking the demand and supply side together. The most successful S&OP team made weekly decisions on resource allocation and available-to-promise rules, which connects S&OP to execution.

In the following subsection an overview of the specifics of S&OP in different industries is given in descending order of S&OP maturity, to show the need and also the possibility of application specific S&OP tailoring (Cecere, Barrett, & Mooraj, 2009):

1. Chemical industry
    - Often leaders in S&OP
    - Swap assets across product lines & companies to maximize utilization and prevent bottlenecks
    - Demand-shaping by price management
2. High tech
    - Short lifecycles
    - High margins on new product launches
    - Demand-shaping by new product launch
3. Consumer products
    - S&OP is a business practice to improve time-to-market
    - S&OP is a tool to align cross-functional teams on market opportunities
    - Demand-shaping by trade promotion activities
4. Industrial manufacturing
    - S&OP elevated to the product-line or divisional level, because at that level resources are shared
    - S&OP is used to get better visibility on demand of complex products
5. Life sciences
    - Lag behind in S&OP due to history of high margins
    - Demand shaping mainly by new product launch
6. Aerospace & Defense
    - Well-defined schedules, rigid cost and price negotiations and penalties lead to a lack of motivation for S&OP
7. Healthcare providers
    - Low S&OP maturity focusing on cost only
    - Demand shaping mainly by price
8. Retail
    - S&OP could be a real boost for retail industry
    - Currently vertical alignment is very weak
    - Demand shaping mainly by merchandising

Some of the above mentioned S&OP aspects in these industries can also be seen in the industry case that is the basis for this work. Like in the chemical and industrial manufacturing industries, asset swaps on product line level are done where they make sense. One example would be shared manufacturing lines for the production of electronic assemblies. These production lines are so generic that they can be used across product lines without costly changeover.

Another aspect is the fast time-to-market that is mentioned as being a S&OP driver in the consumer goods industry. This requirement is strongly hitting the automotive Tier 1 industry as well, driven by the ever increasing software content of the products, and the corresponding expectation of the customers to show product cycles that are known from for example consumer electronics.

The rigid sourcing and product development regime by the customers which is typical for business situations in the industry case, is somewhat comparable to the aerospace and defense industry. This could lead in both cases to a lack of motivation for S&OP.

In literature many different maturity models for the S&OP process can be found (Wagner, Ullrich, & Transchel, 2014) (Lapide, 2005). In order to apply a maturity model to a process typically the process is broken down to sub-processes or practices. A similar approach is for example done in the software development process when applying the SPICE (Software process improvement and capability determination) model.

The different S&OP maturity models were summarized by Grimson and Pyke (2007), however the most important different dimensions were:

- People, process and technology (Lapide, 2005)
- People, process, technology and performance management(Snow, 2007)
- Meetings and collaboration, organisation, measurements, information technology, S&OP plan integration (Grimson & Pyke, 2007)

2.3. The reference S&OP framework

In the previous chapter an overview about the basics of tactical planning and S&OP were given. Most of the literature that can be found is focusing on the areas of consumer goods, where S&OP is already widely deployed. In this chapter a reference S&OP framework will be presented that has been developed by Thome et al. (Thomé et al., 2012). The authors performed a thorough literature research about the state-of-the art of S&OP and structured this information into what they call a “research synthesis framework”.This framework was chosen because it combines both the horizontal and vertical alignment dimensions of S&OP and most importantly it focuses on the basic and thus generally applicable aspects of S&OP. That is essential for the industry case analysis since S&OP will be analysed in a new context (ETO, engineering as supply). This framework will be the starting point for the next section, in which the applicability to ETO and the gaps will be discussed.

In addition to the structure and processes, also the context, the inputs and outcomes as well as the vertical alignment of S&OP is shown in the framework depicted in Fig. 4.

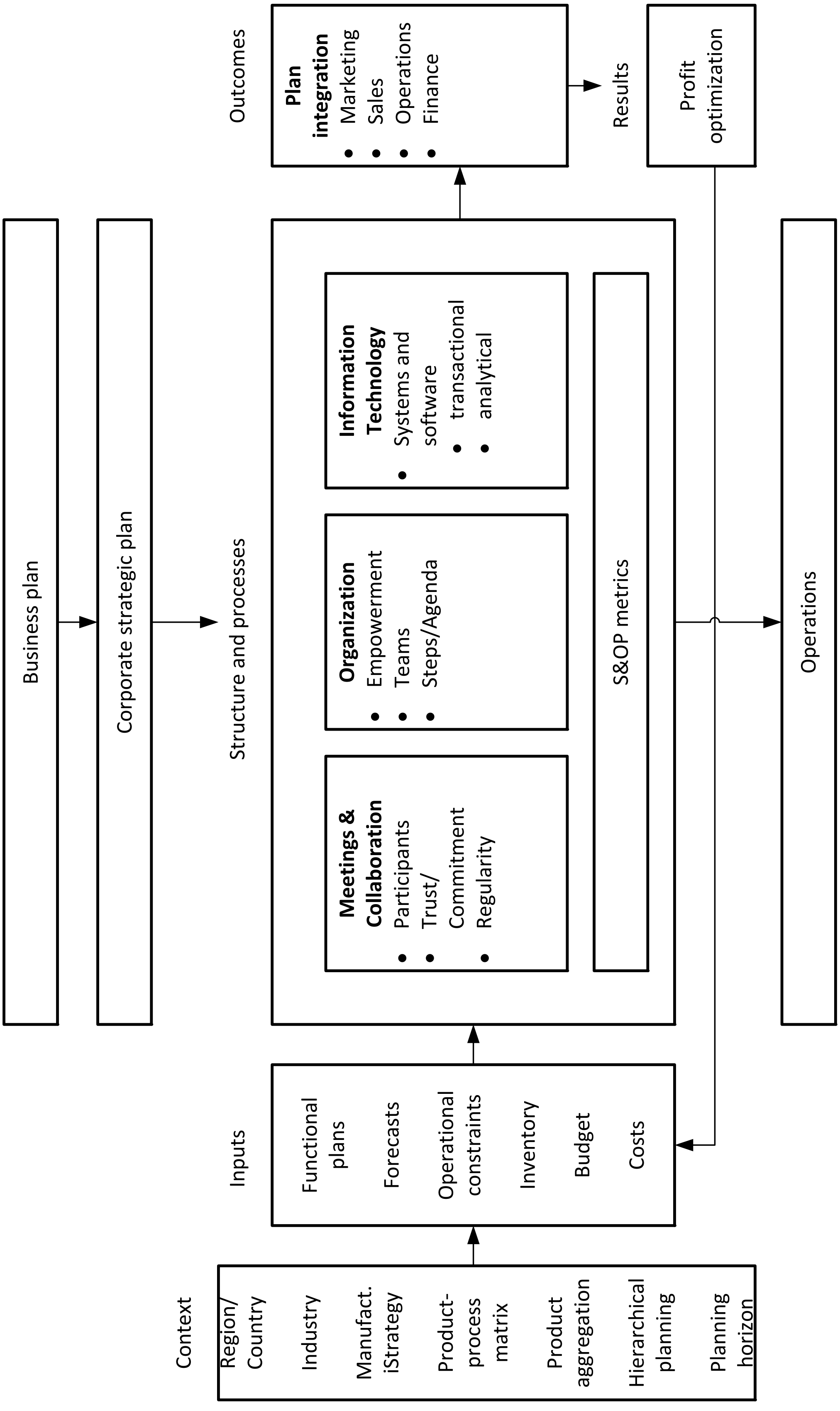

Fig. 4 S&OP reference framework according to (Thomé et al., 2012)

Overview of the framework

Referring to the framework the context can be seen as the definition of the boundary conditions of the particular approach to S&OP. It includes the scope in terms of having a local, regional or global approach, it defines the particular industry which has great influence on the specifics of S&OP (compare page 12), it also states the manufacturing strategy, the product-process matrix (Hayes & Wheelwright, 1979), he product aggregation level that shall be the basis for the S&OP process, meaning if single products or product lines are being considered, also the vertical level of planning (be it more on the strategical or on the tactical level) and finally the planning horizon, which could be short, mid or long term.

In the input section all the information that is being processed in the central process step are categorized: Plans from different business functions (Manufacturing, R&D, …), sales forecasting, operational constraints such as lead times or limited resource availability, inventory, budget and overall cost structure.

Structure and processes basically is taken from the summary by Grimson and Pyke (2007) with the measurement dimension being renamed as S&OP metrics, and the S&OP plan integration dimension renamed to outcomes. The result of the whole process is finally profit optimization of the business. The vertical structure of the framework puts the S&OP process in the tactical planning domain that is below the strategic plan and above the operations activities.

Context

There is a great variety of S&OP relevant information with regards to the different contextual dimensions that were mentioned above (region, industry, manufacturing strategy, …) Especially relevant for this work is that at least for make-to-order and make-to-stock contexts the literature study revealed that there are differences in the S&OP approach (Grimson & Pyke, 2007). On aggregation level most S&OP approaches are on product family level. With regard to the hierarchical level, most studies placed S&OP at the tactical level, whereas some emphasized the strategic dimension, of e.g. capacity increase, which clearly is part of a mature S&OP process(Thomé et al., 2012).

Inputs

The most relevant inputs considered in the papers are sales plan, demand plans and production plans. Typically, this is not enough to establish widely integrated plans of high maturity. Therefore literature also shows procurement, supply plans and finance plans as important inputs. The main constraints that are typically considered in the S&OP process are financial constraints such as profitability, other financial KPIs and production capacity(Thomé et al., 2012).

Structure and Process

Interestingly literature is putting a lot of emphasis on the "social aspect" of collaboration. Trust and confidence in the regular meetings are recognized as being extremely important. While trust and confidence are always helpful in collaboration processes, in S&OP they become vital in order to overcome the strong functional silos that are typical of big organizations. Strongly connected to the personal relationships, there is also the need for organizational empowerment of the S&OP team by giving them dedicated time to perform the alignment task, and giving appropriate management attention to the outcome of the process. Support by information technology is required, as with most business processes, however some authors suggest as pointed out before, that the social aspect is more important than sophisticated IT systems. When starting to implement S&OP into a firm, one should not focus on IT first, but rather strengthen the framework pillars of collaboration and organization.

The S&OP relevant metrics can be grouped into areas of plan (inventory, product development cycle time, …), source (supply side), production (capacity utilization, production costs, …), delivery (customer satisfaction, on-time delivery, …) , S&OP dashboard (measuring the performance of S&OP process itself) and end-results (mainly overall financial profit)(Thomé et al., 2012).

Outcomes

The main output of the S&OP process are integrated plans, meaning improved individual plans which are aligned to each other in order to obtain the ultimate goal which is postulated as profit optimization. Typically incentives and functional reporting lines in corporations do not promote the alignment but rather lead to an isolated or local optimization of plans, which then could even be contradicting. Oliva and Watson (2011) have shown that even if the setting of conflicting targets by management is not stopped, the virtual existence of an S&OP process will improve the performance of the firm. The evidence for the improvement and the reasons for that are not fully clear, but it shows clearly the power that S&OP as a process can have.

2.4. The engineering-to-order scenario

In supply chain planning there are different concepts for product delivery. According to Olhager (2003) four main strategies can be identified with respect to their different order penetration points (OPP). The order penetration point is the point in the product delivery process from when the particular product is directly linked to a customer order (Mihiotis, 2014).Fig. 5 is showing four different product delivery strategies with respect to their OPP. For a make-to-stock product the product is fully finished according to a generic design and production process and is kept on stock until the customer order arrives (Rodrigues & de Otávio, 2010). Typical examples include consumer goods such as washing agents or cleaning papers. No changes to the product configuration can be triggered by the customer order. In an assemble to order strategy certain customization is still possible: Companies like Dell or Apple have an ATO strategy for their personal computer business. Before the final assembly is initiated RAM or mass storage can be configured for the customer specific order. For make-to-order strategies pre-done designs are being manufactured after order receival, example being suppliers of prefabricated houses. Whereas in the ETO situation a customer specific design of the product is entering the value adding chain, and specific engineering or design work has to be done at first.

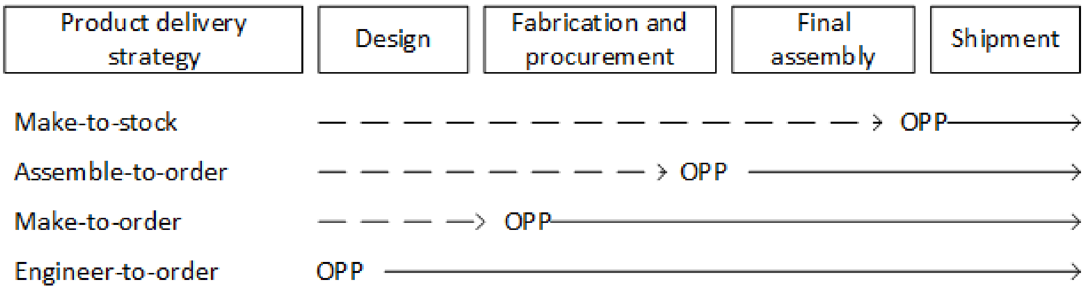

Fig. 5 Product delivery strategies according to the order penetration point (Olhager, 2003)

According to (Mihiotis, 2014) ETO is mainly applied only to low volume products, however the principle behind an ETO strategy can also be applied to high volume products in a business-to-business (B2B) environment. The approaches for mass customization are quite different between B2B and consumer business. Business customers are typically requesting full service and have much higher expectations on accurate fulfillment of their specific requirements. In an industrial environment often critical value is added by customization, leading to a competitive advantage compared to competitors that are not able or willing to fulfill all customer requirements. In addition to the customized product, also accompanying full life-cycle service support is being offered (Mäkipää, Paunu, & Ingalsuo, 2012). Examples for such life cycle service packages in the automotive supply industry would be:

- long spare part service contracts after end of series production

- special contractual obligations on quick turn-around defect parts analysis
- traceability requirements for the whole supply chain

In contrast to the other product delivery strategies mentioned here, for ETO there is the need to have engineering or design work already being done in the quotation or offering phase of the product life cycle. This is required because otherwise there is no technical or commercial basis available to base the profitability and feasibility calculations for the particular product on.

Achieving that high degree of customization that is typical of an ETO driven organization, is a critical challenge for such businesses. Kratochvíl and Carson (2005) have conducted a survey on the quality of the quotation process in some UK and US companies. The main findings were:

- that is very common amongst firms not to cope with the timelines for offer preparation, also due to the engineering effort required.
- Time spent for offer preparation is substantial and strongly increasing with the complexity of the product
- The hit rate (number of awarded businesses divided by number of quoted businesses) can be very low (smaller than 50%), meaning that there is a lot of man hours spent without leading to actual sales
- Even though there is a substantial amount of effort spent in the quotation phase, there is still great risk in the order fulfillment phase due to wrong estimations during quote phase.

One way to improve efficiency in the engineering phase of the quotation phase of an ETO business could be extended tool support. The concept of a design configurator (Mäkipää et al., 2012) would help especially in the critical offering engineering phase of an ETO project. Such a configurator is based on parametric models of the product and automatically yields engineering drawings that can be further used as input to the quote and application projects, thus reducing effort and increasing quality whilst maintaining a maximum of flexibility for the customer. With such a concept even low hit-rate environments can be tackled in an efficient way.

2.5. The applicability of S&OP to ETO

In the previous sections S&OP definitions and the reference framework I will use have been presented and a brief introduction to the specifics of the ETO business situation have been given. The central question is how can S&OP and the reference framework in particular be applied to ETO. How can the ETO specific processes be mapped to the framework and what are the gaps? What has been discussed about this in literature until now?

Sales and operations planning as a business function is not being described in literature as being restricted to MTS or MTO/ATO production strategies. However, there is only little literature available that addresses the special needs of ETO with respect to operations management and especially S&OP(Gosling & Naim, 2009; Hicks et al., 2000; Yang, 2013). Olhager, Rudberg, and Wikner (2001) have described the link between production strategies (i.e. MTO/MTS/ETO/…) and S&OP at the example of long-term capacity management. They explicitly include the ETO situation in their discussion, and their main conclusion regarding ETO is that flexibility is typically winning the orders and that manufacturing in this case is typically not done according to a forecast. They have analyzed the ETO situation with a focus on the low production volume part of ETO businesses and they have not included the engineering aspect, which leaves a gap regarding these aspects.

Generally the horizontal S&OP framework structure of Thomé et al. (2012) which is based on context, inputs, structure and process and outcomes is generic and is expected to be applicable to any business situation. The basic idea that the structured alignment of different plans leads to an improved integrated set of plans can also be applied generically. Also the vertical alignment structure cascading down the business plan via a strategy, the following processes down to operations is generic and is expected to be fully applicable to ETO. The task is to analyze how the content of the framework needs to be adjusted in order to reflect the ETO specific situation.

The big difference between ETO and a typical make-to-stock or make-to-order situation is the specific engineering phase in every product life cycle. The order penetration point is right at the beginning of the design or engineering phase. It is expected that this specific aspect should be one of the main drivers for the need for S&OP in such businesses. Also the need for a (mass) customization strategy is expected to be another specific key driver for S&OP in the ETO situation. The sales or order acquisition activities are basically split up in two parts (Mäkipää et al., 2012):

- External sales part which is similar to MTO/MTS businesses and dealing with terms &conditions and financial aspects
- Internal "sales" part consisting of the engineering offer preparing the basis for the individual ETO program

This organizational difference should also be reflected in the framework.

One example of how the framework has been applied to an industry case can be seen in the work of Ivert et al. (2015). Ivert has analyzed the S&OP process at several industrial food suppliers in Scandinavia and looked into detail about what aspects of the planning process are the most critical with respect to S&OP. The analysis was done using the reference framework by Thomé et al. (2012) that has been explained in detail in a previous chapter. The production strategies of the companies analyzed were mainly MTS or MTO/ATO, but never ETO. There seems to be a lack of empirical studies on the specifics of ETO with respect to S&OP.

So I conclude that the study of Ivert is probably the closest research done with respect to my work, since it is applying an industry case to the S&OP reference framework, while it is not addressing the ETO situation. Generally the framework will be applicable also to ETO, but gaps have been identified that will be discussed in detail together with a proposed framework extension in chapter 4.

3. The automotive industry ETO case

The motivation for this work stems from challenges in a real-world business situation. In this section information about the company, about the respective business processes and the specific challenges are given. In order not to give away business critical data, the industry case is described in a neutralized manner without mentioning real company or product names and avoiding absolute business figures. This chapter is structured as follows: it starts with a description of the company and how it works in a general way, followed by a description of the actual ETO challenge. The chapter concludes with a more detailed description of the R&D capacity planning for the engineering phases of the projects.

3.1. Company description

Company A is a global supplier of parts and systems to the automotive industry. It has subsidiaries in all the major automotive regions which are the Americas, Europe and Asia. The three main operational business functions of sales, manufacturing and research & development are also globally represented. The company is a corporation which is divided into different product-oriented divisions, which in turn are consisting of business units. Each business unit has a defined pool of customers and a defined group of products. This definition helps to avoid overlaps between business units. From a process and entrepreneurial standpoint, the business units are the key organizational unit, since they have great freedom in defining their product strategy, their life-cycle processes and their customer strategy.

Under the umbrella of the corporation, most business units focus on B2B business, whereas some business units are partly in a B2C situation, where the whole distribution channel down to the final customer is under their control. This applies especially for the replacement and aftermarket segments in which automotive parts are directly sold to the final customer through various distribution channels.

In Fig. 6 different value chain configurations that are all relevant for company A are shown. Apart from the B2C situation the business units of company A can act as Tier 1 suppliers when supplying directly to the car manufacturers, or as Tier n supplier. A typical example for a tier 2 situation would be the delivery of an electronic control unit which is being integrated into a system at a system supplier, who in turn is delivering the full system to the car OEM. Even though different tiers are served by company A, the great majority of the business is the business as a Tier 1 supplier, in which the contractual relationships are directly between company A and the car OEM.

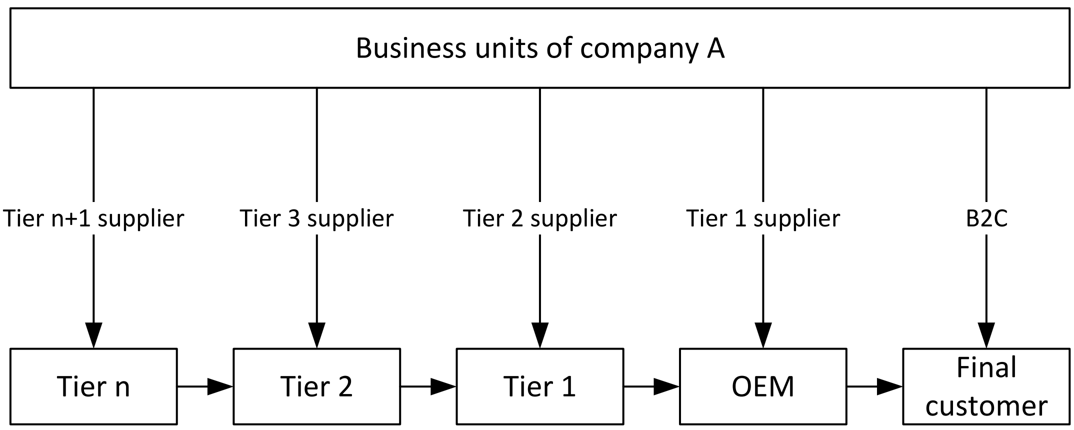

Fig. 6 Value chain for different business situations

For the remainder of the work I will focus on company A's tier 1 position in the value chain, since this is the main business situation for the product case that will be laid out in the next section. Because there are substantial differences between S&OP for B2C business and S&OP for the different tiers (see section 2.2) along the value chain, it is important to make the clear distinction.

The industry case is situated in company A's business unit B, which is mainly catering the OEMs as a tier 1 supplier. Its main products are electronic control units (ECU) and electrical/electronic (E/E) systems for passenger vehicles. These systems are typically integrated into the vehicles in the final assembly line at the car manufacturers.

3.2. How does business unit B function

In this section the typical business process of business unit B is outlined. In the next section the business challenge that lead to this work and the research questions will be explained using the knowledge about the business process.

The entire product life cycle for business unit B's products is organized on a project basis. The project managers are situated in customer centers which in turn are organized in segments which are directly reporting to the head of the business unit. The profit and loss responsibility is organized in the segments and is driven in a customer organization. Cross functions such as manufacturing, research and development and human resources are aligned horizontally to the customer-oriented organization (see Fig. 7). Every project (P1, P2, …) belongs in one customer organization and uses resources out of the cross functions in order to reach the project goal. Most of business unit B's projects are ETO projects, in which an electronic system is specifically engineered to the (mass production) customer order.

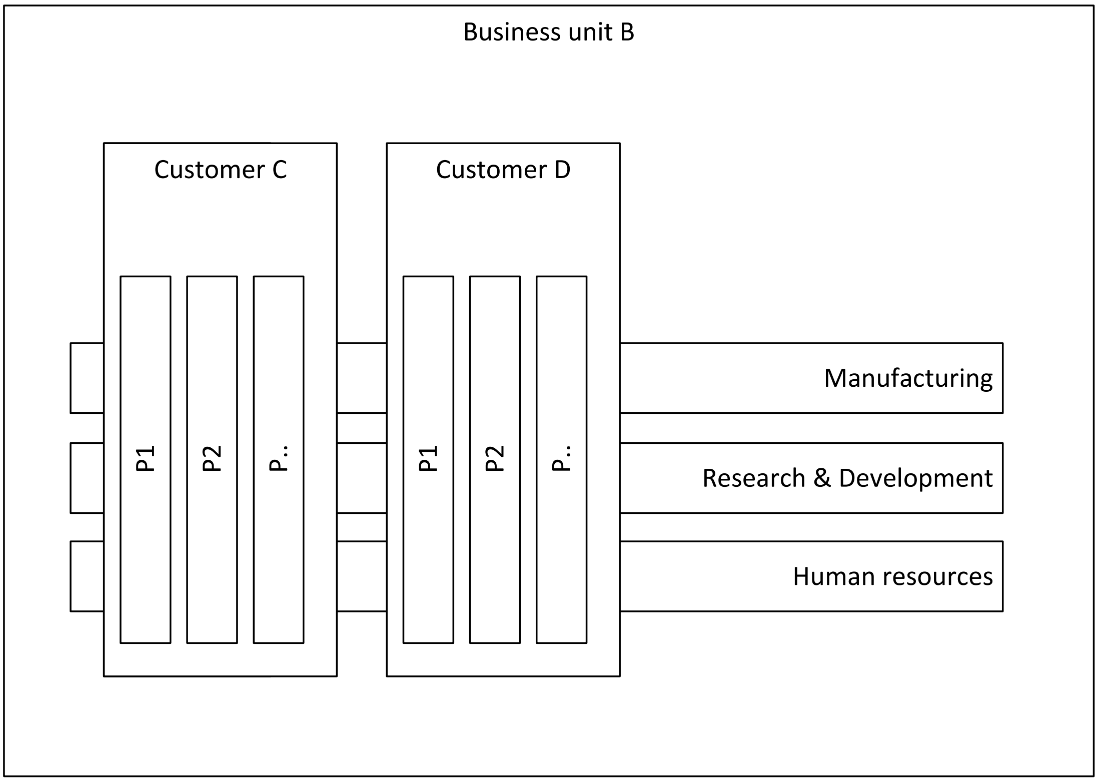

Fig. 7 Matrix organization of business unit B with vertical customer organizations (P/L) and horizontal cross functions.

3.2.1. Sales planning process

Every year business unit B is generating a sales and profitability plan that is communicated and committed to company A's division level. Together with the strategic plan that involves plans like pushing new technologies, entering new markets, or adapting the global footprint, the sales and profitability plan is one of the main interfaces of the business unit to the divisional and corporate level.

In a simplified way the sales plan is generated like that: The main input to the sales plan is the light vehicle production forecast (LVPF) (published by IHS Automotive). It is an industry vehicle volume forecast for the different vehicle platforms and OEMs for a typical horizon of 8 years.

The next step is the identification of potential products/projects with the respective OEMs and car line launches in the respective planning period. These projects are factored into the sales plan with different probabilities that the respective projects (and with them the future sales) in the plan are actually awarded to business unit B. Another important factor is the take-rate of a particular electronic system. In case the system is installed in all the vehicles of the particular vehicle platform, the take-rate is 100% (e.g. airbag control unit), in case of special equipment (e.g. infotainment system) the take-rate assumption is one key source of uncertainty for the final sales plan. This data together with expected product price development and the current and planned customer structure, leads to the sales plan for business unit B.

3.2.2. R&D planning process

In parallel a top down target for the corresponding R&D budget in the planning period is generated. First starting point for the R&D budget is a fixed percentage of the corresponding sales figures. Second boundary condition is an anticipated increase of R&D productivity. Here the underlying assumption is that due to better engineering processes and employment of the platform concept (explained in subsection 3.2.3), more ETO projects can be handled with the same amount of R&D capacity. This leads to a sublinear R&D budget growth compared to the sales growth. The fact that sales volume and R&D spending have a strong proportional relationship is specific to the ETO situation.

After the sales plan and R&D budgets have been fixed, the customer segments are distributing the respective sales and R&D budgets to different project accounts in a business warehouse IT system. The business warehouse system supports planning granularity down to individual R&D cost centers. By this the R&D planning for next year's business is baselined.

There is no formal S&OP process established in business unit B, the sales planning is done by the sales organization. And the top down targeting setting is then executed as described above. However there are yearly alignment meetings between the customer segments (including the sales function) and the operational functions (such as R&D) to align expectations for the next year. While these meetings can be seen as a very first step to an integrated planning, they have proven not to be sufficient to overcome the challenges that are being outlined in the sections below.

3.2.3. Project life cycle phases

Every product or project that is in the scope of the business unit is in one of the below explained phases.

The general project life cycle (PLC) in business unit B is structured as follows:

Innovation phase

New concepts and technologies are developed and tested independent from a customer program. Typically, products which are still in the innovation stage cannot be quoted to the customer, since the maturity of the product concept and technology is not yet sufficient. An example would be a totally new electronic control unit architecture, for example using personal computer based systems instead of dedicated embedded electronic systems for vehicle functions.

Platform development phase

In this phase products are "predefined". Key system components are pre-developed and tested. One goal of this phase is to increase quality for the customer application projects due to increased test coverage and utilization of cross customer leverage, such as economies of scale and horizontal deployment of product improvement ideas. The other goal is to minimize the customer specific development effort, and thus to reduce product lead time and development cost. This phase of the PLC is very critical since it is already directly linked to the customer. If the platform is not chosen well, there are no positive quality, lead time and cost effects, resulting in a competitive disadvantage. In order to answer the research questions, the platform phase needs already to be taken into consideration.

Customer quotation phase

The quotation phase is the first phase in a typical customer application project. It starts with a request for quotation (RfQ) by the customer to all the suppliers that are released by the customer for this particular product group (in our case electronic control units for passenger vehicles). The RfQ document contains typically: Detailed technical specification of the product to be offered, a detailed timeline by when to provide which maturity of the product leading to a vehicle start-of-production (SOP) and the annual production volumes. As a next step, the R&D organization starts to develop the first engineering concepts, ideally based on suitable product platforms. Based on these concepts engineering estimates for the development effort and the product manufacturing costs are generated. These estimates are entered into a life cycle business case calculation which in the end together with the volume scenario yields a price range that can be offered to the customer. Even though platform concepts are employed, the typical ECU product is so specific to the particular customer application that it needs ~ 2-3 years of specific engineering and testing effort before the product can be introduced to mass production. In this phase also the feasibility of the customer requested timing is checked. Here particular notice to the engineering time schedule has to be given, if R&D capacity is not sufficient to provide the engineering work product in line with the customer time schedule, the RfQ cannot be answered positively and has to be rejected. Availability or required invest into R&D capacity is more critical from a timing perspective than for example manufacturing capacity, because virtually lead time zero is required for engineering capacity, whereas invest into the manufacturing process is typically started only one year after business award by the customer.

The quotation phase ends ideally with an awarded business which means that there are contractual obligations to fulfill the customer specific product requirements outlined in the RfQ (by appropriate engineering) and to manufacture the customer released product in the quantities defined by the contract. If the business was lost, the R&D resources that were developing the initial engineering concepts and estimates are released from the quote project and are available for other projects.

Product development phase

In case of award, the project enters the product development phase. This phase can be divided into two parts: Development phase and industrialization phase. The formal project management and reporting is setup, resources from the cross functions (engineering and manufacturing) are assigned to the project. The engineering team is developing the product according to the customer specification and the quality and manufacturing design requirements given by the business unit. The development phase is the most R&D intense project phase, depending on the project size between 10 and 100 engineers can are working on the project objectives, until the design is frozen. After the design freeze, the industrialization phase starts. Manufacturing toolings are installed and the manufacturing process is validated. After release of the production process by the customer, the mass production phase starts. Typical mass production phases in projects for business unit B last 5 years.

3.3. The challenges in R&D management

Since the profit&loss responsibility lies with the customer segments, they have the dominant role in the planning process meaning that planning is initiated top-down both from a sales as well as R&D budget point of view.

Although R&D planning figures are typically entered by experienced project managers (which are partly belonging to the customer segment organization), these planning figures mainly reflect the experience from previous projects. Interestingly enough the R&D ERP system of business unit B provides a mechanism in which the global top-down R&D budget can be assigned by the project manager for detailed planning to the R&D line organization. Then via a workflow this global budget could be distributed by different levels of R&D management to the respective engineering cost centers and time slices.

However, this workflow is not being used due to the efforts and lack of flexibility once the workflow has been started. Even though the idea behind this workflow is very good, it is not being employed. One reason could be that the ERP system is using the same project planning structure for all kinds of (virtual) projects, be it a quote project with a very low probability to materialize or a multi-million application project, thus having a huge overhead for those projects in the system with a low maturity. The result is that, the planning accuracy down to the individual R&D cost centers and over the project life time is not satisfactory. In case of projects that never materialize these flaws do not have any impact, however if a project is awarded sometimes there is no good basis available to ensure a timely start of the engineering activities.

Figure 8 illustrates the process in which the global project budgets from different customer segments are assigned to the different (shared) R&D cost centers. At this instance there is no direct visibility of the business relevance (expected sales, expected profitability, strategic relevance, …) of the respective projects and the probability that the project is being awarded. Leaving the R&D line management with planning figures that cannot easily be used for planning in the respective R&D departments.

For cost controlling reasons there also various top down target for the R&D costs, such as head count (HC) budgets or budgets for external R&D services.

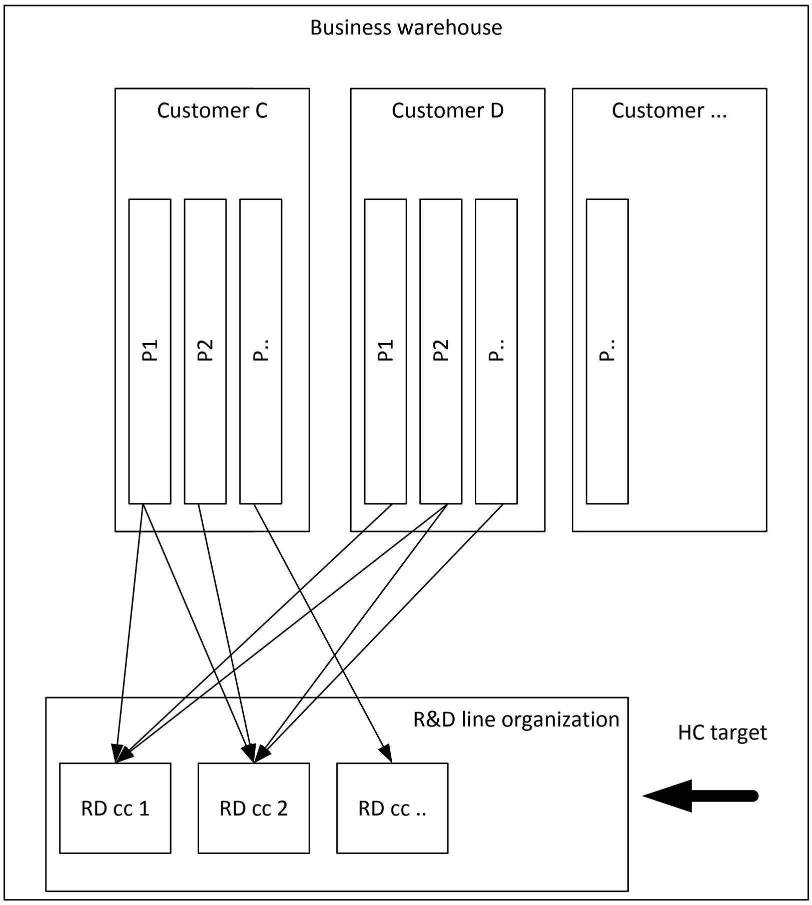

Fig. 8 Distribution of global R&D budget to R&D cost centers

This planning process is working well for products which have high maturity with the following properties

- commodities, for which the take-rates are known
- no new technology
- project management is familiar with the respective challenges
- the customer base and number of projects is well understood
- the R&D community has a lot of experience
- also the customer is familiar with the product

Due to the generally lower business uncertainty in this kind of situation, the missing alignment is impacting the final (R&D) planning quality to a lesser extent.

The product that shall be dealt with in this work is the innovative product L. Product L is quite new to the industry, so both the OE customer as well as the whole business unit organization have not yet collected a lot of project experience. However, product L fits quite well into the existing product portfolio of business unit B. Both the customer base as well as most of the technology needed to develop and manufacture product L are known in the business unit and can be carried over from similar products. The main challenges for handling product L in the R&D domain can be summarized into two areas:

1. Technical challenges
    a. Still weak/new platform concepts
    b. Unexpected technical challenges
2. Uncertainty regarding required R&D capacity
    a. How fast is the product penetrating the market? What are the take rates? What is the final demand for the product and thus for engineering?
    b. Is the customer base the right one? How big are the differences between the different ETO products? Is there an optimum between serving all customers with highly differing products, which is the situation with the highest R&D demand, and a limited number of (ideally profitable) projects which even fit better to the platform and thus require less R&D capacity?
    c. How successful will the customer segments be with acquisition of projects? So how much of “short term” engineering capacity which is required for the acquisition phase is required versus how much of this short-term capacity will be needed in the long run for full development projects? This is highly impacting the utilization of the engineering capacity.
    d. What is the actual accessible market? Do we have all the potential opportunities on the radar in good time? This question

is important regarding the flexibility of the engineering capacity. If customer intelligence is not sufficient there will always be many unexpected/unplanned projects to work on, because nobody knew about these opportunities. While this is surely not a problem with mature products/markets, it is highly troubling in an innovative ETO environment.

While the technical challenges must not be underestimated in terms of their project impact, the biggest impact for the business regarding product L is the lack of an aligned R&D capacity planning.

The problem that arises is that the above described alignment process between the customer segments responsible for sales (growth) and the R&D function is not capable to manage the high degree of uncertainty present for an innovative product like product L. The resulting lack (i.e. lack of engineers with appropriate competency level) or wrongly allocated R&D resources can lead to delays in the development phase of application projects and the inability to quote for projects, which in turn reduces "unexpectedly" the planned order intake.

The main challenge for R&D management is to be able to prepare suitable engineering capacity with the given set of inputs. In order to achieve this goal the forecasting and planning processes have to be improved.

4. Analysis of the industry case with respect to S&OP

In order to answer the below research questions, the industry case is analyzed accordingly.

- *Which aspects of the existing Sales & Operations Planning practice can be applied effectively to an automotive Tier 1 engineering-to-order industry case?*
- *How can Sales and Operations Planning help to improve the business performance considering mainly the planning and development phases of such an engineering-to-order program?*

First the industry case planning process is analyzed in the light of the S&OP reference framework and an overview is generated. Then an analysis with regards to ETO is performed, compiling the ETO specifics in the industry case. Finally, a proposal for an ETO-adapted S&OP process using the framework and the industry case as reference is drawn up.

4.1. Planning process applied to the S&OP reference framework

From the start of the analysis it was clear that business unit B does not have an official S&OP process with a process description, a dedicated team and dedicated S&OP metrics. However, there are some aspects in the planning process which show elements of an S&OP process in the first maturity stages. There are first examples of cross functional target settings. For example, there are sales or order intake targets for R&D management regarding product group L. Since sales targets are typically given to people in the customer/sales organization, this is already one cross-functional element.

The planning process is being analyzed using the elements of the S&OP reference framework for structure: Context, input, structure and process and outcomes.

4.1.1. Context

The contextual environment for which the S&OP is being drawn up is defined by the industry case business situation. The business consists of new innovative products, so there are partly unknown challenges and generally a high award uncertainty due to the fact that the product line is not only new to company A but generally new to the whole industry. The manufacturing strategy is ETO and ideally based on platform concepts. The engineering and sales functions of the business unit are organized in a matrix organization, which is important when analyzing the topic of horizontal alignment.

4.1.2. Input

Business unit B is generally using sales forecasts as input for its planning. The sales forecast stems both from internal sources such as formal contacts of the sales organization with the customer about future business development, as well as from external sources such as industry reports. Planned order intake and sales targets also enter as inputs. The main constraint is the fixed R&D budget for the next year that is being allocated top-down to the different customer centers. There is an awareness in the business unit that the R&D capacity is restricted and that this is a limiting factor for the sales growth. Manufacturing capacity is not directly entering as a constraint, even though manufacturing footprint limitations are being communicated throughout the planning chain. The main goal of the planning process is to reach the respective sales and R&D targets.

4.1.3. Meetings and Collaboration

The planning process for the yearly planning is initiated by the sales community without formal meetings. The sales plans are discussed in sales planning meetings in the customer organizations, but not with the cross-functions in a formalized way. There are alignment meetings between R&D and customer organizations once a year, where mutual understanding of the future business is achieved. While these meetings are formal and planned they have a rather low frequency. However, these meetings do not have a strong planning focus, but are more facilitating a general exchange on technologies and customer trends and opportunities. Trust and commitment are generally high in these meetings, but the subject of the meetings is not an optimization of the planning.

Even though there is a yearly plan of which projects should be tackled in the next year, in principle there would be continuous feedback throughout the year about the planning accuracy and the actual project status. Customer programs are quoted, awarded and also lost throughout the year, leading to an immediate need for readjustment of the plans. One way to provide improvement would be to employ in addition to regular meetings also event-triggered meetings on every program quotation, award or lost business as suggested by Grimson and Pyke (2007).

Furthermore, these meetings are separately happening between the R&D organization of a particular product line (in our case product line L) and the respective customer segments. There are no overall alignment meetings between multiple customer segments and the product line. Such integrative S&OP meetings are missing in the current planning process. Because R&D resources are shared resources that quickly can be redistributed between customer segments, the importance of integrative meetings is even greater.

4.1.4. Organization

Since there is no formal S&OP process established in business unit B, there is no dedicated S&OP team. The sales and acquisition planning is mainly done by sales and project managers in the respective customer segments without any formalized feedback loop with operations (R&D/manufacturing)

management. Every customer segment has one responsible person that collects the input from all its sales and project managers, compiles the plan and checks it with the respective top down targets on sale and R&D expenses. These persons could be potential team members for a formalized S&OP team structure. Management is mainly involved in releasing the plans, but does not play a strong role in the alignment work.

4.1.5. Information technology

Business unit B uses for the R&D part of the projects an SAP based ERP system. This system supports planning and controlling for all the R&D projects in the business unit. This system is linked to the hourly booking systems of the individual R&D cost centers, by which it can also provide actual R&D expenses during the time the project is active. The project reports out of the system regarding the planned R&D expenses for the next year have to match to the top-down R&D budgets. No other functionalities of this ERP system are being used in the normal business. Capacity planning down to individual engineers, or more complex functionalities like what-if analysis are not supported by the system. While IT support is not the main ingredient to a well-functioning S&OP process, in a multi-project environment where interdependencies between separate projects are highly relevant, especially what-if analysis would improve the planning process greatly. Another problem is the low granularity that the system features: quarterly planning from a timing perspective and R&D cost center from a resource point of view. Even if there were more frequent alignment meetings there is no way to visualize the results in time slices shorter than a quarter and capacity chunks of less than a R&D cost center.

4.1.6. S&OP metrics

The current metrics that are reported and tracked on product group level are profitability in terms of return on sales, the R&D to sales ratio and the best-cost ratio, which is a KPI that is showing the ratio between R&D expenses in best-cost countries (countries with lower salary) and high cost countries (countries with western European salary levels). When analyzing the S&OP relevant metrics in the industry case, a lack of appropriate metrics can be identified, such as hit rate (awarded projects/offered programs), product development cycle time, planning cycle time, planning accuracy (actual projects vs. planned projects), R&D productivity and R&D utilization. The introduction of such metrics are key in order to steer future S&OP activities.

4.1.7. Outcomes

The outcome of the current process for business unit B, are sales plans which have the respective sales and R&D expenses included. The plans lack integration since they rely on top-down targets for the individual functions, and are not result of a continuous alignment between the different functions. No formal consideration regarding existing capacity of the cross-functions and product complexity/customer mix inside a product group has been given. A clear link is missing between strategic decisions done by the top management and the operational task of distributing limited resources between several acquisition and development projects.

In parallel, there are R&D capacity and footprint plans, which are mainly describing a continuous growth of the capacity with an increasing part of the workforce in best-cost countries in order to reach the top down R&D expense targets. These plans are developed in a reactive way, which is basically using the forecasted sales growth with a fixed (and decreasing) ratio of R&D expenses. A full integration of the sales and R&D planning aspects is missing in the current planning process of business unit B.

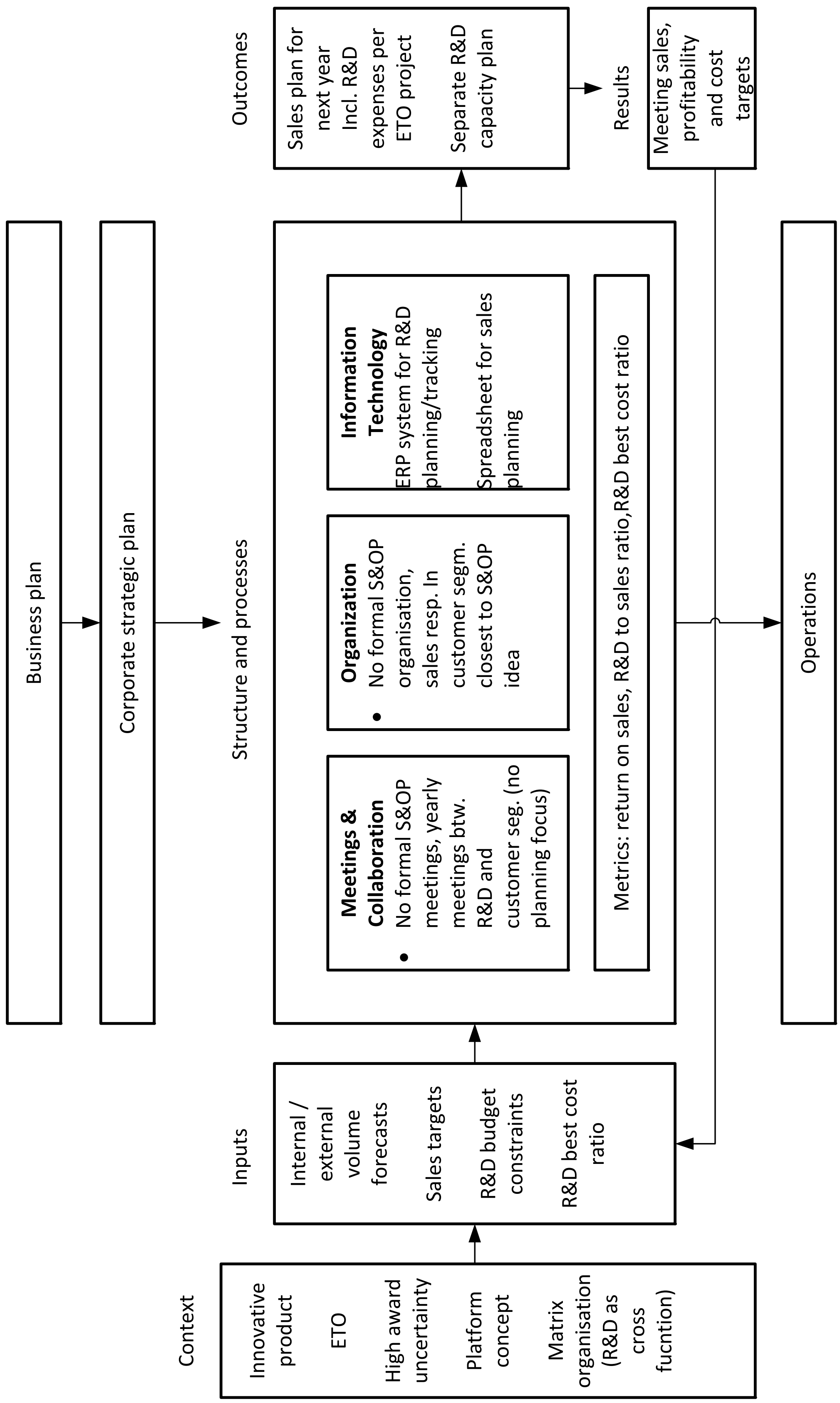

Fig. 9 Current state of planning process for product group L applied to the S&OP reference framework by Thomé et al. (2012)

4.1.8. Summary of the current planning process applied to the reference framework

The above analysis findings are visualized in

Fig. 9. For the industry case it can be summarized that there is no formal S&OP process established for the business planning regarding product group L. The mapping of the current planning process to the reference framework yielded that a formal S&OP organization is missing, that no S&OP specific metrics are existing and that the planning process is missing inter-functional elements, which can be seen in the disconnected IT systems (R&D and sales) and the separated sales and R&D capacity plans. The only link between the plans are matching top-down cost targets. The process for bottom up alignment is not established.

4.2. Analysis of the ETO specifics aspects in the industry case

ETO as a manufacturing/business strategy has been put into the element of context of the reference framework, since the specific engineering process which is being planned in parallel to the sales needs special attention also for a potential S&OP process to be established for product group L. The basis for the industry case analysis are collected business observations and experiences.

4.2.1. Sales and engineering plans

One ETO specific planning aspect that has been identified in the industry case, is the existence of a sales plan which mentions in addition to the respective projects with the corresponding sales, also the respective R&D budget which is allocated to this specific project. In MTS or MTO businesses, the engineering efforts are distributed evenly to all the products, whereas in the industry case the product specific most R&D efforts are assigned to the respective product only.

When looking at a typical S&OP division into a sales plan and a production plan, in the ETO case the production plan needs to be split up in two parts: namely the engineering plan and the production plan (see Fig. 10). In the industry case, there are no separate plans in the engineering domain, but at least the available R&D budget is globally distributed to the different projects.

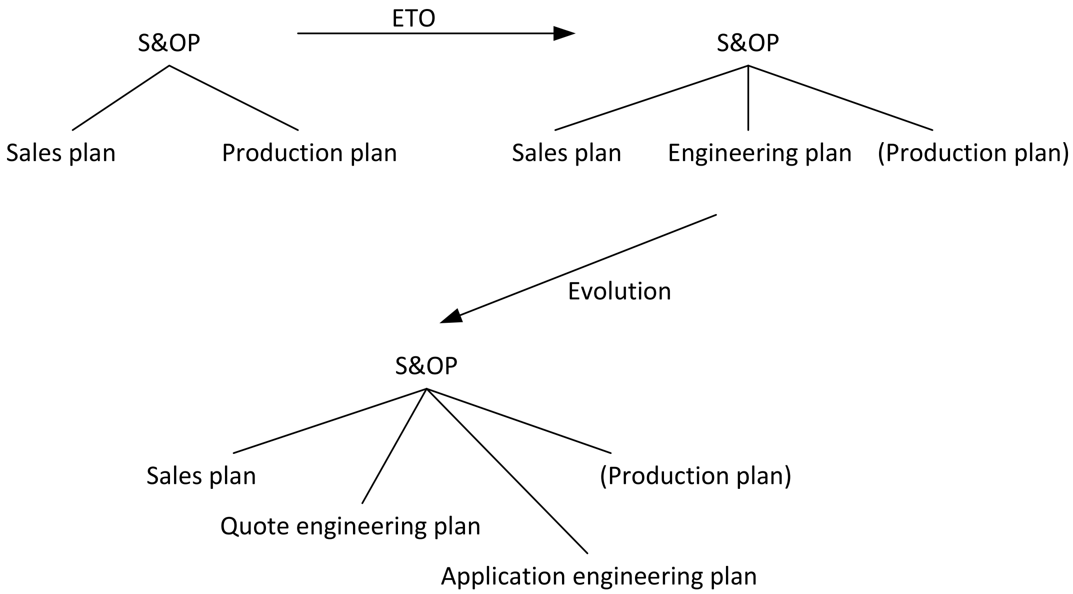

Fig. 10 Change of S&OP scope for ETO environments and evolution with separate quote and application engineering plans

In the industry case production plans were not part of the yearly alignments, the focus in terms of strategic and tactical production planning is more on achieving a balanced manufacturing footprint.

The next improvement step would be the introduction of separate quote engineering and application engineering plans, allowing for more transparency and higher planning accuracy.

The yearly alignment meetings on technology and customer trends which are already formalized in business unit B, are also ETO specific since they help both to align internally the platform projects, which finally reduce R&D capacity demand, as well as help with some kind of demand shaping. Demand shaping can be achieved by showing the customers proactively different innovation/platform concepts with the idea to move the customer request more towards the own technical core competency.

4.2.2. Priorization and decision processes

The fact that there is a hit rate smaller than hundred percent for acquisitions regarding product group L, leads to the problem that in order to get full utilization of the engineering capacity, this capacity has to be overbooked during the planning phase. The allocation of R&D capacity to different projects during a planning period is mainly done according to the first come, first serve principle. So there is no process to manage the given R&D capacity with the goal of e.g. profit optimization in mind. This would be a typical outcome of an S&OP process.

The decision process which should create balance between the R&D demand side, which in the industry case are customer segments requesting either quote or application development activities, and the R&D supply side which is R&D capacity, needs to be formalized and would be one key driver for S&OP. The necessity of clear decisions has been recognized by the company and thus several decision options have been developed in the management team: One is to reduce the demand side, by refusing to quote new projects, or actively reduce the number of new projects. The other option is to increase the supply side which is hiring of additional engineering staff or buying external R&D capacity by subcontracting or outsourcing.

Another decision option which is vertically positioned more towards the strategic planning level would be the reallocation of R&D resources across product groups. In case market opportunities are of strategic importance capacity increase could also be facilitated from other business units or divisions. The S&OP organization should have escalation channels to top management to be able to facilitate such resource balancing on a higher organizational level.

So the continuous reallocation of engineering capacity due to awarded/lost business is another ETO specific aspect which needs to be taken into account for S&OP.

4.2.3. Optimization of product/customer mix

For product group L the proportional relationship between final sales and R&D effort to generate the sales (quote and application development efforts) is not constant for all product/customer mixes. Some customers require very specific developments, because they have detailed knowledge about the product functionality and therefore can define very specific requirements, whereas other customers do not go into detail with their requirements and thus can be served by a platform product with only minimal adaption. This relationship (R&D to sales ratio) is being monitored in business review meetings, however it is not a figure that is used consistently in the planning process. There are projects with low sale and comparatively high R&D effort, and vice versa. Strategically the planning process should steer the product/customer mix towards the low R&D/sales ratio projects. This means priorization of "easy to handle" customers and towards generic products and avoiding highly specific products with limited sales. This would be another goal or KPI that should become part of a ETO specific S&OP process.

4.2.4. Ideal positioning of the order penetration point within the ETO range

The order penetration point for product group L is basically between the platform and the application development phase of the product life cycle. By definition the OPP for an ETO situation can never be shifted past the application development point. However, business unit B is serving a wide customer base with different needs in terms of customization. Some require highly customized products, others are willing to make compromises in terms of customization if lead times and development costs can be reduced.

Therefore, an integrated planning should also involve the aspect of mass customization, by which an overall lower R&D to sales ratio can be reached.

4.2.5. Product/Market-related aspects

Due to the innovative character of product L, which on top is also engineered to order, the uncertainty regarding technical specification and thus the engineering effort for the different projects is very high, which is a specific property of innovative ETO business. This high "effort" uncertainty in the planning phase is surely one driver to promote S&OP.

Also a lot of the OE customers do not have appropriate visibility about the possibilities that product L offers, therefore the procurement on OE side is not planned timely, which in turn leads to surprising or unplanned RfQs, demanding R&D capacity for quotation support where none was planned. The ETO specific challenges that the product group L is facing have been identified previously in literature and include problems with meeting the timelines during the quotation phase, often due to lack of or wrongly forecasted R&D demand during the planning phase (Mäkipää et al., 2012). Tight timing in the quotation phase needs also to be considered as a critical context variable for the industry case. Even though substantial efforts are spent on the acquisition there is still a hit rate on the order of 50% to be considered. If the hit rate for product L quotations could only be increased by a small percentage by employing S&OP, this would immediately have positive business effects.

Hit rates could be improved by having an aligned approach between the customer segments and the R&D functions which customer/programs have the highest award probability when looking both at the commercial as well as technical aspects of a quote program. It is key that the alignment has to be done across the different customer segments by a separate (i.e. S&OP) team. Only by employing a separate team the required independence for true balancing of R&D capacity to the customer programs with the highest overall business benefit can be achieved.

4.3. ETO-adapted S&OP process proposal

In chapter 2 the applicability of S&OP to the ETO situation was discussed and gaps in the current S&OP “state-of-the-art” have been identified. In the previous section the ETO specific aspects of the industry case have been related to the S&OP process. In this section these findings are being compiled and an ETO adapted reference framework is being presented in Fig. 11.

The adaption of the different aspects of S&OP is discussed using the same structure that was used in the previous sections:

4.3.1. ETO specific context elements

The context of ETO is by definition the main driver for the adapted S&OP process, however the main contextual change with respect to the business setting should be the switch from a purely matrix driven organization, in which the plans are mainly done in the different domains, to an approach where the success of the product line is the first thing to look at. This would imply a product line based planning and tracking of the business development. Other business units in company A that are also operating in an ETO mode, do not have such a matrix organization but they have strong product lines with full profit & loss responsibility. It would be worthwhile to perform a similar analysis like done in this work for ETO industry cases featuring a different organization context (e.g., product line P&L instead of customer segment P&L)

4.3.2. ETO specific inputs

The main addition to the element of input are technical product roadmaps. Effort needs to be made to get the best possible information about the customer technical roadmap. The knowledge about the future plans of the customers regarding features and requirements for the product group, will be processed by the S&OP team in order to get better assumptions for take-rates, R&D effort estimations. This information will also enter the internal technical roadmap process in order to match the product platform as much as possible with customer expectations.

The internal platform roadmap is also a key input to the process, since it is the basis for decisions like priorization regarding the product/customer mix and it will be used to steer the business more towards customer programs which are fitting better to the respective product platform.

4.3.3. ETO specific meetings & collaboration structures

One of the key findings of the analysis is that a continuous repriorization and redistribution of the engineering capacity has to take place. This will be facilitated by dedicated meetings in which the S&OP team is always checking the status of application programs, running quote projects, lost/awarded projects and potentially new opportunities which have not been planned because they were not known to the organization.

Achieving the right mix between customization and platform approach is one important element for business success, the continuous adaption of the product platform development also needs to be aligned in dedicated meetings. A third set of meetings needs to deal with the review of the product/customer mix.

The participants of these meetings need to come from engineering, from customer segments (i.e. sales) and from product marketing. The engineering participants need to represent application development, quotation support and platform development. In a typical R&D organization this would be three different people from the engineering domain. The representation of the customer sales segments is more difficult since the number of relevant/potential customers is constantly changing. Therefore, all customer sales segments that have currently stakes (actual programs or planned future sales) in the product line, need to delegate a participant. The third function of product marketing needs to be represented by a product marketing specialist dedicated to the product line and bringing mainly the sales expectations of the whole business unit with respect to the product line and market intelligence such as reports and trends to the S&OP meetings.

The frequency of the meetings is a key question. As pointed out in subsection 3.2.2. from the industry case observation, there an alignment meeting with similar goals is held once a year. Since the S&OP meeting outcomes are needed to operationally redistribute resources, this frequency is much too low. The choice of frequency is a trade-off between the participants' time effort (including preparation of the meeting) that is needed for the meetings and the efficiency to deal with short-notice changes in the business environment. Such short notice changes could be unexpected RfQs, or operational problems such as unexpected technical challenges in the development or the production of awarded programs. Since a monthly frequency will, lead to a lot of ad-hoc firefighting meetings, due to the low "reaction" time, which in turn will bypass the S&OP process, a biweekly frequency should be employed and tested as starting point.

All these meetings results are input for the final S&OP decision meetings in which the update of the respective plans is being agreed by the management. For the ETO situation these decision meetings should be held in front of management which is from a line organizational standpoint above both the R&D as well as the sales functions.

4.3.4. ETO specific S&OP organization

Cecere, Barett, et al. (2009) are stating that successful S&OP introduction projects focus 50% of their efforts on change management and the rest on process alignment and S&OP technology introduction. Whilst this analysis was done for S&OP transformations in classical production system environments, there is no reason why it should not also be true for the ETO situation.

Therefore, the introduction of a formal S&OP organization is not necessarily the first step in a potential implementation plan.

As a first step the participants that have been identified in the previous subsection should come together under the leadership of the product marketing specialist. This could be implemented quite easily since no changes in the line organization need to be done. The main challenge is to achieve empowerment of the team and to make sure that the decisions made in the management meetings are based on the outcomes of the S&OP process and that they are executed. Strong barriers to that are the typically strict separation between the different customer sales segments and the engineering domain in a matrix organization (as described in chapter 3). As with any change process in an organization there is the need for strong change sponsors in top management positions. Again due to the matrix organization this role can only be done by the head of the business unit., which is not efficient in the long run.

Therefore, as a second step a dedicated line organization should be formed. Since there are a lot of cross-functional alignments and decisions to be made, a formal S&OP organization would ensure the required independence from the various domain targets. However, we suggest to have two separate S&OP organizational units (teams), one in the R&D domain and one in the sales domain. These teams join together for the respective S&OP meetings, but their background is different. This split reflects the equal importance of engineering and sales domains in the S&OP process and is backed up by the experience Mäkipää et al. (2012) made for the sales teams in the engineering-to-order situation. The teams should have a scope that extends across the different customer segments, and across the different R&D domains respectively. The “internal” S&OP team is also responsible for the correct product platform roadmap which optimizes the overall business performance of the company.

4.3.5. ETO specific S&OP metrics

New ETO specific metrics shall be introduced to measure and control the effectivity of the S&OP process. The percentage of started acquisition projects with respect to awarded projects shall be monitored as hit rate. An optimized product/customer mix should lead to a higher hit rate.

A measure for how well the product platform is matching the customer requested performance shall be defined. One possibility to define such a metric could be the number of reusable requirements (stemming from the platform development) for a new customer product as a fraction of all the requirements for the new product. Such a "match-to-platform" metric could be introduced quite easily since the typical automotive engineering process is already requirements based and typically supports all kind of requirements based metrics.

Also the acquisition planning accuracy shall be monitored, since this is a key input to the S&OP meetings. Here a metric could be generated as follows: the number of actually performed acquisitions in a given time period as a fraction of the planned acquisition as of the beginning of this time period. The target of this KPI would be to achieve 100%. Percentages lower than 100% would indicate a lot of dummy projects in the planning and figures above 100% would mean that there were a lot of unexpected acquisition activities in the reference time period and that the sales organization needs to do more field work to get the forecast as close as possible to the actual market demand.

The R&D to sales ratio also has an ETO specific aspect. Since the S&OP process should also steer the organization towards a more favorable balance between required R&D spending and respective sales, this KPI is another long-term measure for the performance of the S&OP organization.

Also planning cycle time, which would be a measure of how often the S&OP teams meet and the plans are updated is an important metric, especially in the starting phase of an S&OP process to directly monitor its activities.

Finally, R&D utilization as a metric should be installed, in terms of how much of the planned engineering capacity is actually represented in the actual sales planning documents. Again a R&D utilization close to hundred percent would be an indicator for well aligned plans.

Overall financial figures such as return-on-sales of the product are added because they will give general feedback about the business performance. However, these figures are heavily impacted not only by the S&OP performance, but mainly by other influence factors, such as the overall competitive market environment and the buying power of the customers.

4.3.6. ETO specifics S&OP outcomes

The final result of the S&OP process is also in the ETO case aligned plans. As the analysis showed we propose to generate two different plans for the engineering domain. One plan focusing on the application development and thus ensuring the required capacity for the awarded product developments. The other plan focusing on the quote engineering activities. The idea is that these two plans make it easier to allocate available resources to either activity and also to get full visibility for which activities new capacity needs to be installed (either by hiring or outsourcing).

Another important ETO specific output of the S&OP process would be the product platform roadmap. This is not a typical output of a MTO/MTS S&OP process, but since the appropriate platform concepts are key for business success in a challenging ETO environment, they have to be updated and checked continuously by the S&OP teams. The roadmap as an output is then worked on by the respective platform engineering teams, which are responsible to pre-develop appropriate engineering concepts. These pre-developed concepts lead to higher reuse and thus to a lower need of engineering capacity both in the quote as well as the acquisition phases.

The aligned sales plan itself with the sales volumes of the running products and the products planned to be awarded in the next planning period is an integral part of every S&OP process. The ETO specific aspect is that every line item in the sales plan is directly connected with the respective engineering expenses that are needed to realize the sales.

Facilitated by the S&OP process, the sales plan shall contain the product programs with the highest award probability, the most favorable R&D / sales ratios and the products with the best match to the product platform.

4.3.7. ETO specific S&OP results

The ultimate result of the S&OP process should be to better meet the sales, profitability and cost targets given by management. Sales targets which are typically broken down from company level to the different business units could be better met, because firstly the operational performance during the entire product life cycle would improve and secondly the basis for the upcoming sales plans is more reliable. Profitability targets will be met better partly due to the optimized product/customer mix and partly due to improved operational performance (e.g. more efficiently allocated engineering resources). The cost targets are strongly correlated to the sales and profitability targets, the improvement is mainly due to the optimized resource utilization.

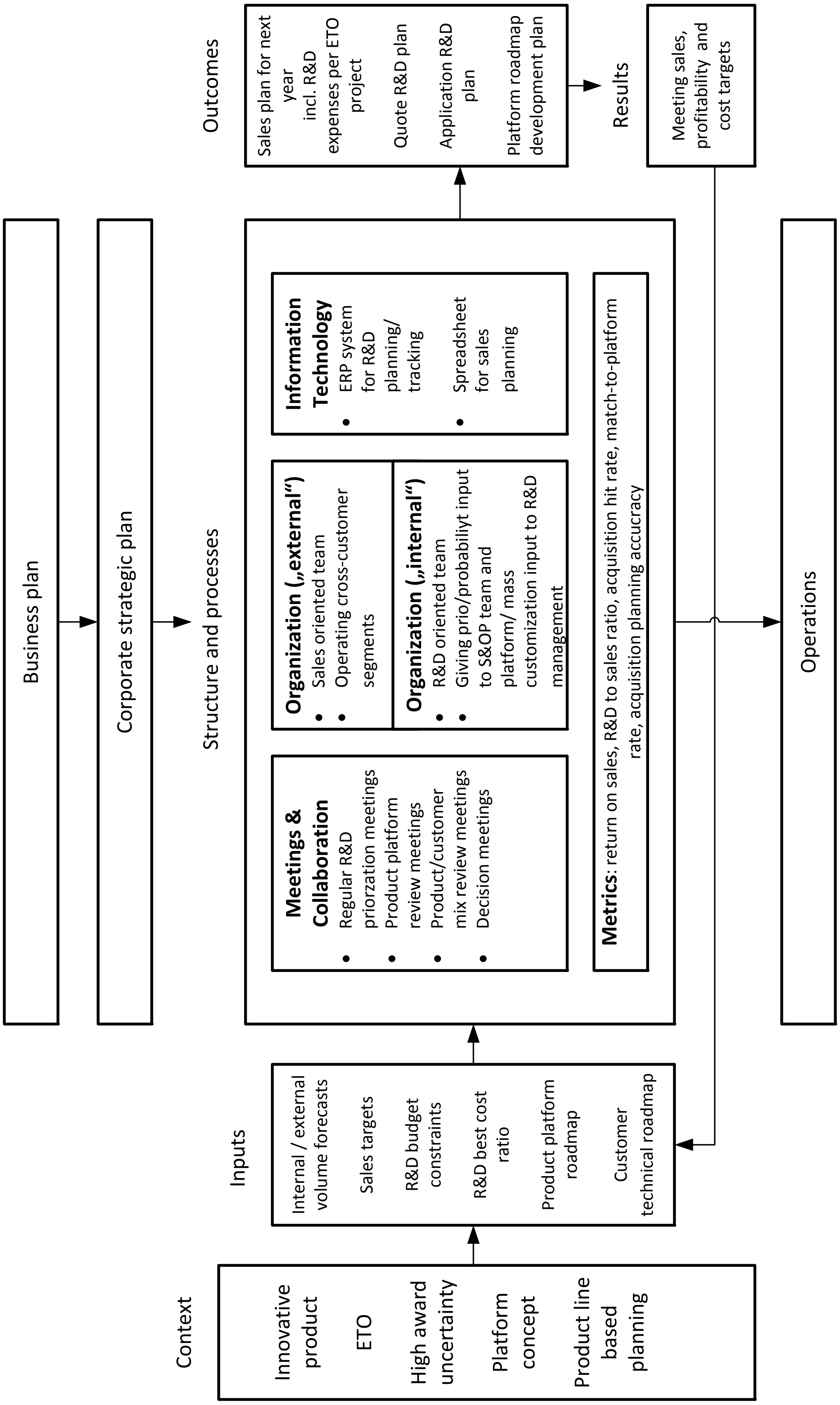

Fig. 11 Proposal for an ETO adapted S&OP process shown using the reference framework by Thomé et al. (2012)

5. Discussion

In the discussion first the findings from the previous chapter are interpreted using input from previous literature and the result, namely the adaption of the S&OP framework is explained. Secondly the question whether the S&OP practice can rightfully be employed for ETO situations in a real world situation and if so how it can be employed is being discussed.

5.1. Interpretation of the ETO - S&OP framework analysis

It seems that S&OP will be helpful especially in demanding planning environments. In the Ivert et al. (2105) paper the demanding aspect is the perishability of the products and raw materials, and also uncertainty of the availability of raw materials due to bad crop or weather situations. In the discussed industry case the main planning challenge is the uncertainty regarding the required engineering effort due to uncertainty regarding technical challenges and the success of the respective product line in the market. Whereas the food processing companies analyzed in the Ivert et al. (2015) paper already employ some kind of S&OP process, in our industry case, S&OP is only in the very first stages without a real representation in the organization. When looking at the overall S&OP maturity ranking across industries (Cecere, Barett, et al., 2009), there is evidence that this particular industry case is not an exception. Industrial manufacturing is generally slightly behind consumer products in terms of S&OP deployment. However, the common denominator is that S&OP is a means to improve performance in business situations with uncertainties on the supply and demand side of operations, also for ETO businesses.

Trappey, Trappey, Chiang, and Kuo (2009) already described the idea that the engineering resources in an ETO environment need to be utilized for the right products in order to guarantee business success and that special strategies like product portfolio management can be employed to achieve that and select the “right” products. While they promoted portfolio management, they did not propose an integrated planning like it is done in S&OP. The potential effectiveness of the adapted S&OP process to address these questions lies in the combination of platform concepts, quote planning and application planning. The idea that there is a continuous feedback loop for the platform concepts is one of the main proposals of the adapted framework. These concepts are under constant pressure to generate new order intake, are therefore subject to strong “internal” competition, which will lead to a selection of the best platform concepts. To bring the “product(roadmap)” aspect also into the S&OP equation when thinking about capacity is a key extension when compared to scientific work done on S&OP previously. The problem of supporting the management in an ETO company especially in the quote phase regarding available operational capacity has been analyzed in literature and proposals for detailed linear programming approaches to solve the topic have been presented (Carvalho et al., 2015), but not in the cross-functional way which is typical for S&OP.

Mass-customization strategies have been discussed by Mäkipää et al. (2012)) as a means to reduce engineering effort and thus increase flexibility to cope with various market demand levels without adding additional engineering capacity. In the adapted framework proposal this aspect is represented by the platform concept.

Another interesting aspect is the product demand uncertainty in case the product is very innovative, as in the automotive industry case. According to Cecere, Barrett, et al. (2009) innovative industries like the high-tech industry are quite advanced in employing S&OP, exactly for the reason to sense demand fluctuations. Again this supports the potential effectiveness of S&OP in case the (ETO) product is innovative.

The same paper mentions that one of the main success factors for integrated business planning is the focus on common plans and not on one-figure targets. If the proposal for the adapted S&OP framework was followed, the alignment on the one-figure R&D top down target would be replaced by a common set of R&D planning documents, which could be a step towards better business performance.

5.2. Real-world application of the ETO adapted S&OP process

Whether the drafted S&OP process proposal can be employed effectively in a real-world situation also depends on the nature of the ETO business. The ETO business situations can differ widely depending on the industry and the specific products of the company. There is a span between very low volume highly customized situations, like the manufacturing of special machines, on the one hand, and high volume ETO situations like in the automotive industry case on the other hand. For the former, the introduction of a specific S&OP team could potentially be too high effort and due to the low number of concurrent quote and application activities, the effort will probably not pay off. For the later, the S&OP process with the framework developed in the previous chapter could be a starting point. If there is a management decision to invest effort into the improvement and/or installation of a S&OP process this work should give the respective "S&OP implementation teams" valuable insight and a framework to build on.

Because the conventional S&OP process (dealing with sales and manufacturing) is typically not matching with the ETO situation, in real-world ETO businesses S&OP is typically not employed. Providing a proposal for an ETO adapted S&OP framework, which is putting a focus to the product and the engineering, and thus aims to answer "real-world ETO" challenges, could give these businesses a good reason to install such an S&OP process.

6. Conclusion and further research

The motivation for this thesis stems from a real-world challenge in the automotive industry. This thesis aimed at analyzing an automotive engineering-to-order industry case in the light of sales & operations planning and finding out if concepts known from other industries than automotive and other production strategies than engineering-to-order could be employed to solve the problem.

There is no profound previous literature available on S&OP in the context of ETO, so this work is giving first ideas on how S&OP could be interpreted in an ETO organization with the focus on automotive tier 1 business. The specific relevance of the engineering aspect in all the product life cycle phases has been explained in detail and the respective consequences for S&OP have been shown.

A proposal how to apply the general idea of S&OP as tool for tactical planning to the ETO situation has been developed. The industry case has been analyzed and the resulting ETO adapted S&OP framework are the result of the work. The analysis led to the conclusion that most elements of the S&OP practice as described in literature, such as an own S&OP organization, structured meetings and the generation of aligned plans can be applied to the ETO environment. Concrete ideas about how to set-up a S&OP process with the focus on the engineering part of the value chain have been outlined. These ideas can directly be used by the interested practitioners in the field of ETO as a starting point for their analysis or implementation efforts. Practical ideas about which plans should be integrated in the S&OP process and which metrics should be generated to measure the performance and steer the process have been generated.

The introduction of a formal S&OP process in the organization seems to be one (appropriate) way of handling the problem of engineering capacity distribution in an ETO business environment. The improvement in sales and engineering/operational plan quality, is expected to finally lead to an improved financial performance of the company.

Next steps need to be taken in two directions: Firstly, the sketch of the ETO adapted S&OP process as an outcome of this work, should be employed in a real business situation to verify the expected benefits for the overall business performance. If there is a decision to come up with a dedicated S&OP organization, a first step could be the installation of only one of the proposed S&OP teams (R&D) in only one product line, to keep the additional headcount low in the beginning. If the metrics show an improvement of the planning quality, next steps like full deployment of the S&OP organization could be taken. Such as step would have to be accompanied by an appropriate change process backed up by top management in order to get the required empowerment for the S&OP team.

Secondly there is a huge potential for further research in this area. There is the general need for more case studies regarding S&OP in ETO businesses. To validate the qualitative results from this work, quantitative studies would be needed using for example surveys or mathematical modeling. The paper of Carvalho et al. (2015) being an example of such a quantitative work. Also the effect of the respective industry (automotive/industrial/medical/...) on the relationship between S&OP and ETO needs to be analyzed by case studies across industries.

Looking into the future the production strategy of ETO is offering the highest level of customization for a product. At the same time mass customization will become much more important in the future, because it is offering still untapped economic growth potential, with Industry 4.0 being one of the important enablers in this context. That means that the design or engineering portion in future production systems could potentially become much more important. While not all products with lot size zero, will be completely new designs, platform and design-configurator concepts will become key in this aspect. It would be a very fruitful field of research to investigate this area with respect to the tactical planning level and to look for the application of S&OP methods also in this context.

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