Case studies in Advanced Planning Systems for Tactical Planning in Process Industries

Ola Cederborg

Division of Production Economics
Department of Management and Engineering
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Abstract

This thesis focuses on the use of Advanced Planning System (APSs) in the tactical planning process. In addition, there is a special focus towards process industries. The overall aim is to find out if and how APSs can support the tactical planning processes and add value to the company. A discussion on APSs as such is also presented, as the general definition of APS is unclear.

The study is based on three case studies, first a longitudinal case study at a single company, second a in-depth case study at the same company and last a multiple case study at four Scandinavian companies. The case descriptions provide answers to the overall purpose of the thesis, but they also contribute to the general knowledge concerning APSs, as they describe industrial use of these systems.

The study reveals several improvements that companies have achieved by implementing APSs and it conclude that APSs can support the tactical planning process. The improvements are seen either as results of process changes needed to implement the APS or the APS itself. Among the improvements, centralizing, automatizing and streamlining of the tactical planning processes are three of the most prominent. But several other improvements are also found, for example improvements concerning the customer service level and inventory levels.

Although several successful implementations, it is not uncommon that implementations projects fail, which is why companies need to be careful when deciding to invest in an APS. Factors found to be linked to success concerning APS implementations are discussed, with the APS’s fit to the company’s processes and existing systems along with promotional activities, either by a project champion or the top management, are found to be important.
Foreword

'Do you tell me, please, which way I ought to go from here?'
'That depends a good deal on where you want to get to.'
'I don't much care where --.'
'Then it doesn't matter which way you go.'
'--so long as I get somewhere.'
'Oh, you're sure to do that... if you only walk long enough.'

Dodgson (1865)

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Ola Cederborg
Thesis outline

This thesis entitled *Case studies in Advanced Planning Systems for tactical planning in process industries* is a Licentiate thesis in Production Economics at Linköping University. The outline of the thesis is as follows. First, the frame of reference that the thesis is based on is presented, followed by an account on and discussion of the methodology. The appended papers are thereafter presented briefly, before the results and conclusions. Last, the papers (listed below) are appended in full.

Appended papers

**Paper 1**

*APS for Tactical Planning in a Steel Processing Company*

*Cederborg, O. and Rudberg, M.*

This paper is submitted for publication in *Industrial Management & Data Systems*. A draft version of the paper was presented at the 15th International Annual EurOMA Conference, 15-18 June, 2008, Groningen, The Netherlands

**Paper 2**

*Capable-to-promise for Segmented Customers in a Capacity Constrained Manufacturing Environment*

*Cederborg, O. and Rudberg, M.*

A previous version of this paper is submitted for publication in *Production Planning and Control*. A draft version of the paper was presented at the 16th International Annual EurOMA Conference, 14-17 June, 2009, Gothenburg, Sweden

**Paper 3**

*Assessing factors affecting results of APS implementations*

*Cederborg, O.*

A draft version of this paper was presented at the 17th International Annual EurOMA Conference, 6-9 June, 2010, Porto, Portugal
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Papers

Paper 1. APS for Tactical Planning in a Steel Processing Company

Paper 2. Capable-to-promise for Segmented Customers in a Capacity Constrained Manufacturing Environment

Paper 3. Assessing factors affecting results of APS implementations
1 Introduction

This thesis concerns the area of advanced planning systems (APSs) as used to support the tactical planning process in manufacturing companies, with special focus on the process industry. In this chapter the background and the reasons for conducting this research are presented, as well as the aims and objectives with the research.

1.1 Background and problem area

For many years companies have been pressured to find new or better ways to create customer value, leading to them searching in all directions for methods to improve their overall performance. As a result of this a growing interest in logistics and supply chain management (SCM) emerged in the 90’s, as it was seen as a way of both reducing cost and enhancing service (Christopher, 1998). Now, more than a decade later, SCM, is still a topic of immediate interest which can be described as a holistic approach to managing across the boundaries of companies and processes and an understanding that overall business performance is a function of the whole chain rather than individual companies (Slack et al., 2006). The planning of operations and processes within a supply chain is a demanding task, as the multitude of products all need to share the supply chain’s limited resources. This supply chain planning (SCP) has for many years been a top priority for many companies, as the holistic approach to the coordination and integration of key business activities is a means to decrease supply chain costs and hence increase profits (Gupta and Maranas, 2003). For the last decade APSs have been promoted as enablers of a more efficient planning of the entire supply chain and therefore the expectation on APSs have been high. This thesis aims at investigating APSs usage and exploring how companies can utilize these systems to their best benefit.

In the 90’s a new set of IT systems began to enter the market, systems meant to keep track of and streamline the information flows within a company (Davenport, 1998). These systems were called enterprise resource planning (ERP) systems, a term which is believed to have emerged from the two terms materials requirements planning (MRP) and manufacturing resource planning (MRPII) (Klaus et al., 2000). MRP and MRPII had until then been one of the leading planning philosophies in manufacturing companies around the world. The ERP systems as such were an extension from MRP and MRPII systems, with means to handle functions outside of the manufacturing such as finance, sales, distribution and human resources. But in addition to the proposed improvements, ERP was adopted by many companies as a way of addressing legacy systems software that were not Y2K compliant (Jacobs and Weston, 2007), which also was a factor that affected the successful introduction of ERP systems.

Akkermans et al (2003) concluded that the four major limitations of the first generation of ERP systems were:

1. Their insufficient functionality to cross organizational borders.
2. Their inflexibility to the ever changing supply chain needs.
3. Their lack of functionality beyond managing transactions.
4. Their closed and non-modular system architecture.

But both Lütke Entrup (2005) and Gupta and Kohli (2006) states that an important characteristic of ERP systems is that the modularity allows implementation of selective modules to fit the needs of a specific company. The ERP systems of today may thus have emerged beyond some factors that the Akkermans et al study showed, but the other three limitations are still valid concerning ERP systems. The inflexibility concerning business processes and organization (1 and 2) forces companies to thoroughly consider how much they can adapt to the system without losing business advantages (Shehab et al., 2004; Davenport, 1998; Slack et al., 2006). Issues related to the planning procedure
(3), are; fixed lead times as the base for the plan, batch sizing without considering interdependencies and long processing times leading to low planning frequency, which in turn leads to plans being out of date towards the end of the planning period (Lütke Entrup, 2005). In the planning process there is no possibility to take into account both the need for materials and the need for production capacity at the same time, which would give a better and more reliable plan. APSs aim at doing just that, taking into account several constraints at the same time and optimizing the plan with the goal of minimizing cost or maximizing profit. The idea is for APS to be an improvement of some of the limitations to the ERP systems and work as an add-on to ERP systems. The aim is for APSs to improve the planning process itself, which can be described as:

“The process of setting goals for the organization and choosing various ways to use the organization’s resources to achieve the goals.”

(APICS, 2008)

Imagine a manufacturing company with a make to order situation with almost 200 products groups, each group consisting of several products, a make to stock situation with 360 stock keeping units (SKUs), almost 100 stock points worldwide, more than 10,000 customers and fluctuating demand. Add to this a production with more than 100 defined resources, 20 possible bottlenecks depending on the product mix, small batch sizes and high product variety and you will certainly see the complexity associated with the company’s planning. Choosing the best ways to use the organization’s resources with respect to the overall goals of the company is way beyond what is possible to do without the use of supporting tools. The described example is from a specific company, but the situation is not unique, it is the reality for many companies today, which explains their search for planning support. APS offer this support and several companies have chosen to implement one or several APS modules, but has the APS improved these companies overall performance? Research on companies that have implemented APS have revealed several positive effects, see for instance Stadtler and Kilger (2008), but is this the whole truth? Are the success stories presented in literature a representative selection of companies who have tried to implement APS? There is no argument about that the promising results when looking at the systems as such, but do they deliver what is expected of them and how should companies act to make the most of their APS?

1.2 Scope

The scope of this thesis is aspects concerning the implementation and the use of APS in Scandinavian process industries. This is partly a practical and financial setting, meaning that the Scandinavian countries are easy accessible and that the funding of the project by VINNOVA (The Swedish Governmental Agency for Innovation Systems) require usability for Swedish companies, whereas Scandinavian settings can be considered applicable for Swedish companies.

Findings by Gruat La Forme et al. (2009) show that a majority of the APS modules implemented at 50 studied companies supports their downstream processes, concerning forecasting and sales. Also, the study points to the fact that 53% of the implemented modules concern the tactical level, 36% concern the operational level and only 11% concern the strategic level. On the other hand, Wiers (2009) states that a majority of APS implementations are in the production scheduling domain, which also were one of the findings of a study conducted in the beginning of this project (Cederborg and Kjellsdotter, 2007). Nevertheless, this study puts focus primarily on the tactical planning process, including the APS modules; multi-site master planning (MP) and demand planning (DP). The tactical planning process concern several important tasks with a mid-term planning horizon. One of these is forecasting future demand on an aggregated level. This forecast is used when planning how to utilize the available production capacities of one or more production facilities in the most efficient way, which also is a tactical planning task. The aggregation on this level helps to simplify the model’s
complexity, which allows for the use of optimization engines to improve the planning (Stadtler and Kilger, 2008). This makes the tactical planning level an interesting process to study.

The demand fulfilment module (DF) is also included in the scope. This module uses results from the two modules DP and MP as input and is often implemented together with these two modules. One reason for the implementation of DF is that the question of improving the reliability of delivery promises is a very important task when implementing an APS (Gruat La Forme et al., 2009) and DF is a module with the ability to improve this measure. Hence DF is a more or less integrated part of many APS solutions and included in the study. This gives a scope not only concerning the actual planning, but also covering the utilization of the plans in DF, illustrated by the white modules shown in Figure 1. Explicitly stated, the scope of this thesis is the implementation and use of the three APS modules MP, DP and DF.

![Figure 1 Scope of the thesis](image)

1.3 Research aim and research questions

There is sometimes a view that APSs solve the planning problems within any company and create an optimal plan. Partly, this is because of researchers emphasizing the usability of APSs in industry settings and pointing out that APSs are a possibility for companies to increase their overall competitiveness (Lütke Entrup, 2005; Bixby et al., 2006; Brown et al., 2001; Neumann et al., 2002). If this was true without exception it should hence be beneficial for any company to implement any APS, but criticism is raised that the systems are not able to support all processes and contexts (Gruat La Forme et al., 2005; Setia et al., 2008). Both Gruat La Forme et al. and Setia et al. call for more research studying the real added value of APS implementations in the contexts of several companies’ unique situations and contexts. Also, Wiers (2009) opinion is that there is too few accounts on implementation issues concerning APSs. The overall aim and hence the purpose of this research is:
...to find out if and how APSs can support the tactical planning processes and add value to the company.

In order to achieve this there is a need to get a better understanding of the industrial use of APS, which is lacking in the literature today. Not to say that there are no published accounts on APS in industry, but there are too few to get a good and firm base. Because of this, it will also be beneficial for this research, and the academic community, to study APSs in an industrial setting, to add to the body of knowledge concerning practical use of APS.

As stated above, the overall aim of this research is to find out if and how the tactical planning processes can be supported by APS. The tactical planning level is supported by the APS modules MP and DP and the result from these modules is utilized by DF (Figure 1). This means that, in order to refine the research, the first part of the aim can be split into the following three broad research questions:

RQ 1. How does the use of an APS affect the Demand Planning process?
RQ 2. How does the use of an APS affect the Master Planning process?
RQ 3. How does the use of an APS affect the Demand Fulfilment process?

A company’s goal is always economical, one way or another, which means that possible changes in processes need to be realized as real value if they are to be interesting for companies, which also is stated in the overall research aim. This raises the question of what real value is to a company? Lower inventory levels are not in itself real value, but inventory cost money and less inventory cost less money, hence the value of inventory reduction. Increased service level leads to increased customer satisfaction, which leads to increased customer loyalty, which leads to increased profitability and revenue growth (Kaplan and Norton, 1996). The reduction of inventory and the increase of service level are two effects that are experienced in APS projects (Kilger, 2008; Jonsson et al., 2007), but of course there are more effects that companies have experienced. If these effects lead to real value, it is interesting for companies to strive for them, and it is an interesting phenomenon to study. So in order to deepen the understanding of the answers to the first three questions there is also a need to understand the concept of effects and how the effects can be achieved, which is why the following questions needs to be answered.

RQ 4. What effects can be expected from APS implementations?
RQ 5. How can a company achieve the effects from an APS implementation?

To process of deriving and answering these five questions is described in Figure 2. Initial theoretical studies and a market analysis (abridged in chapter 2.4) led to identifying the diverse opinions on if APSs actually are beneficial for companies and organisations.
The uncertainty concerning if APSs are beneficial or not first led to three research questions, focusing on how APS affect the tactical planning processes. The stated uncertainties and the three questions in turn raised the question of effects from APS, as this is an important issue in the possible future industrial use of APS. This led to two more questions, focusing on effects and the achieving of them. These questions are divided into two groups, the first concerning how APS affect the tactical planning processes and the second group focusing on the effects of APS and how to achieve these effects. Continuing theoretical studies have been undertaken parallel to the case studies, which are meant to answer the research questions. A description on how the research questions are connected to the case studies and to the three papers is provided in chapter 3.2.
2 Frame of reference

This chapter provides the frame of reference which is the foundation of this thesis. It gives insight into some planning concepts and gives a more detailed description of APS. Also, the term APS as such is discussed and described, as the definition of APS is somewhat uncertain and fuzzy. The first part presents an overview of the evolution of APS and the different systems are explained further in the following sections.

2.1 Planning Systems – a brief history

First, the intention is to shed some light on the evolutionary path of APS. The information in this chapter is based on Jacobs and Weston (2007) and Mabert (2007) unless otherwise stated.

One of the first contributions to the development of material planning systems was the use of mathematical formulas in order to decide batch sizes in production (Harris, 1913). Harris’s, now well known, economic order quantity (EOQ) was one of the first applications in the production area and it has, since then, been studied by many researchers and is still used in companies around the world. Approximately 20 years after Harris, R. H. Wilson presented a method that handled the complex problem of warehousing in two parts, part one was to decide the size of orders (EOQ) and part two was to decide at which inventory level a replenishment order would be initiated (the reorder point). Wilson’s work led to the development of several different, but basic, stock management systems that were executed manually with pen and paper or with simple tabulating/accounting machines. During the Second World War, Ford Motor Company produced B-24 bombers with a maximum production rate of 25 planes per day. In total, each plane consisted of about 30,000 components, which is why a complicated system with tabulating machines, punch card machines and so on was used. This system was one of the first MRP-system and this logic is still used in different applications today.

In the 60’s the general primary company focus was on cost, which resulted in product focused production strategies based on mass production and cost minimization. This led to the introduction of computerized order point systems, with calculations of EOQ and economic reorder points on a weekly basis, which met the needs of the companies at this time. During this decade new MRP systems, with new computer technology, were introduced. These included the best known methodology in order to handle materials planning and scheduling for complex products. These new MRP systems used the new technology’s Random Access Memory to store data, which actually was what made these systems possible since database searches no longer had to be done sequential. The early MRP systems were big and costly, especially since they were built on mainframe computer systems that required massive technical support. The continuing development of storage media with more capacity is a major part in the development of integrated business systems. In 1975 IBM launched the Manufacturing Management and Account System (MMAS), which some consider to be the precursor of today’s ERP-system. The system created accounting transactions, work costs and updated forecast that were based on both stock and production transactions. It could also generate production order from customer orders through a BOM.

At the start of the 80’s American industries faced challenges with their production processes. Oliver Wight, an expert in production control and one of the pioneers in MRP during the 60’s, noticed this and emphasized that the companies needed integration between production, planning and other production functions. Wight minted the name MRP II, which he defined as:

“a system that includes the financial planning as well as planning in units; it also includes a simulation capability. From a management point of view, MRPII means that the tools are being used for planning the activities of all functions of a manufacturing company.”

(Wight, 1984).
This was a starting shot for ERP, although the term ERP had not been minted yet. MRP II was developed to include technical areas such as production development and production processes in combination with the previous functions production planning, purchasing, inventory control and distribution (Klaus et al., 2000). In the early 90’s the analytical firm Gartner Group minted the term ERP, with the intention to mark that a new era of enterprise systems had started. ERP is a comprehensive system meant to integrate all processes within a company by using a central database where all data is stored (Figure 3).

**Figure 3 Anatomy of an ERP system (Davenport, 1998)**

The database draws data from and feeds data to applications supporting a varsity of functions within a company, including finance, manufacturing, inventory, human resource, service, sales and delivery (Davenport, 1998).

The production planning in ERP systems is based on the MRP methodology, which assumes that; capacities are infinite, all customers, products and materials are of equal importance and certain parameters (such as lead times and routings) are or can be fixed (David et al., 2006; Waller, 2003). These drawbacks have cleared the way for APS, which try to find feasible, near optimal plans across the supply chain as a whole, while potential bottlenecks are considered explicitly (Stadtler and Kilger, 2008)

### 2.2  Production and Supply Chain Planning

The planning of a manufacturing company is usually based around the following questions: What should be manufactured? How much should be manufactured? When should the manufacturing take place? What resources should be used? (Olhager, 2000) In most companies the planning is divided into three hierarchical levels; strategic, tactical and operational planning, where the first usually
extends beyond two years and coincides with the time horizon for changing the supply chain layout. The second ranges from three months to two years and coincides with the time needed for changes in the production capacity. The operational planning level ranges from zero to three months and covers the time needed to effect changes in the production. Planning far into the future requires products to be bundled into groups and time buckets to be larger (weeks or months instead of days or hours), the longer the horizon the larger the product groups and time buckets (Krajewski et al., 2007). This is a way of eliminating or evening out uncertainties and fluctuations in, for instance, demand and capacity. The aggregated plan on higher levels is disaggregated throughout the company, to set frames for the more detailed plans on lower hierarchical levels.

A common method to use, still today, is MRP, which is based on the bill of materials (BOM) and basically explodes the requirements for a top level product through the BOM and hence generates the requirement for all components individually (Browne et al., 1996). MRP systems can also be enhanced with pegging, which is a method to keep track of relations between orders, so that identification of dependent demand is possible, which is useful when unplanned events occur. The planning horizon in MRP must be at least as long as it allows planning the production of all possible products, but usually it’s longer to facilitate visibility of future capacity requirements (ibid.).

The MRPII system uses the MRP logic as a base, but it also transforms the materials demand into capacity demand. Through backward and forward planning, a possible production schedule can be derived, which is followed by various capacity adjustments. Although the system calls for several loops in the process, the practical implementation of MRPII were in most cases linear (Klaus et al., 2000). This could point to the fact that the system as used in industry performed worse than it could if installed in its most advanced way, which is also seen in some APS implementations (Cederborg, 2010).

In ERP systems the planning procedures as such is not far from MRPII, the big improvement is that ERP can integrate all organizational parts and hence enhance the visibility throughout the organization (Slack et al., 2006). The planning in traditional ERP starts with the loading, which is the allocation of work needed to fulfill the demand or the forecast to certain processes. After the loading the sequencing takes place, where there are possibilities to prioritize work based on for instance; customer priority, due date or other sequencing rules. The scheduling is the next step and this is the production of a detailed timetable showing when activities should start and end (ibid.)

The planning of supply chains increases the planning complexity as more participants in the chain are involved in the processes. When the planning concerns more than one company, as it often do in supply chains, the departments, divisions, factories and individual decision makers make the planning imbalanced and it is often hard to centralize the decisions, leading to sub optimization and a non-holistic view of the supply chain (Pibernik and Sucky, 2007). Frisk et al. (2010) suggest that an independent model might be easier for the different companies to accept, than one company in the supply chain making all the planning decisions. To solve this, APS could be a solution, as these systems are able to conduct planning of the entire supply chain.

2.3 Advanced Planning Systems

Advanced Planning System is a term that was minted by several system vendors in the 90’s as they launched their systems (Stadtler and Kilger, 2008). A reason for them to do this was to distinct their new planning support systems from the traditional planning systems provided within ERP. A problem with this way of inventing the term is that there is no firm definition to be found saying what should be included within a planning system to call it APS.
This is not only an APS related problem, Klaus et al. (2000) describe the same problem with ERP and have three distinct definitions; the generic ERP, the packaged and pre-configured ERP and the installed and individualized ERP. According to Klaus et al., the characterization should focus on the generic packages as all configurations and adaptations have made a generic description impossible. The concept Supply Chain Management is also subject for inconsistent views as some people for instance use it as a synonym for Logistics and some use it to mark the integration of all key business processes in the supply chain (Cooper et al., 1997).

Even the abbreviation APS isn’t consistent as some authors use APS as an abbreviation for Advanced Planning and Scheduling, but the meaning is in fact the same as for Advanced Planning System (APICS, 2008).

2.3.1 The definition of APS

The Association for Operations Management (APICS) define APS as:

“Techniques that deal with analysis and planning of logistics and manufacturing during short, intermediate, and long-term time periods. APS describes any computer program that uses advanced mathematical algorithms or logic to perform optimization or simulation on finite capacity scheduling, sourcing, capital planning, resource planning, forecasting, demand management, and others. These techniques simultaneously consider a range of constraints and business rules to provide real-time planning and scheduling, decision support, available-to-promise, and capable-to-promise capabilities. APS often generates and evaluates multiple scenarios. Management then selects one scenario to use as the “official plan.” The five main components of APS systems are (1) demand planning, (2) production planning, (3) production scheduling, (4) distribution planning, and (5) transportation planning.”

(APICS, 2008)

APICS’s definition of APS is quite broad and does not clearly state any firm boundaries when deciding if a specific system from a specific vendor is APS or not. Still, it puts focus on some of the characteristics of APS, which are important to keep in mind when discussing these systems. According to APICS an APS should therefore:

1. Use advanced mathematics to perform optimization or simulation.
2. Consider finite resources.
3. Include at least one of the following components:
   a. Demand planning
   b. Production planning
   c. Production scheduling
   d. Distribution planning
   e. Transportation planning

To state that an APS should include some predetermined modules would be to narrow the definition too much, as there are many vendors focusing on just one or two modules. Also, there are possibilities to utilize one module for several tasks, for instance the tactical planning module can under some conditions be used for more detailed scheduling. The characteristics of the system as such should decide if it is an APS, not the width of it. The use of optimization is an important characteristic, as it both improves the possible solutions and decrease the computing time dramatically. Also, the consideration of finite resources should be included, as this is very important if the created plan should be applicable in practice.
The book Supply Chain Management and Advanced Planning, edited by Stadtler and Kilger (2008), does not explicitly define APS. Instead it states that the term has been launched by different software vendors independently, which is why they put focus on identifying the common, underlying structure of the most commonly used APS. One conclusion is that APS consists of several software modules, each of them covering a certain range of planning tasks according to the supply chain planning matrix developed by Rohde and Meyr (2000) (Figure 4).

![Supply Chain Planning Matrix](Figure 4)

In the supply chain planning matrix (Figure 4) two dimensions are used when classifying the planning tasks; planning horizon and supply chain process. The tasks are those that typically are present in most supply chain types (Fleischmann et al., 2008). With the supply chain planning matrix as a base, Meyr et al. (2008) lists which of the processes in the matrix that are supported by which APS modules (Figure 5), which gives a structure of APS that can be used when describing what module is studied and hence, which planning problems the module in question supports.
Strategic network planning covers all long-term planning processes with extra weight given to plant location and design of the physical distribution structure. Demand planning (DP) covers the strategic- and mid-term sales planning. Demand fulfilment and ATP/CTP (DF) is used in the short term sales planning, e.g. when making delivery promises. Multi-site Master planning (MP) can be seen as the hub of the planning modules, where the supply chain’s resources are taken into consideration in the mid-term planning level. Production planning and scheduling covers processes such as lot-sizing, machine scheduling and shop floor control. Transport planning and distribution planning is often covered by two different modules, which together covers the mid- and short-term distribution processes. Purchasing and material requirements planning is connected to the mid- and short-term procurement processes. These processes are often supported by the ERP system. Although, when it comes to material or components an APS can take into consideration alternative suppliers, quantity discounts and lower or upper quantity limits.

Looking at APS in this module-wise way fills the purpose of organizing the systems structure into smaller parts which makes it easier to study. Also, it is in parity with many of the vendors’ views, which makes it useful for practitioners.

Lütke Entrup (2005) uses the module matrix (Figure 5) as a structural base when discussing APS, but he also lists a number of common characteristics among APS:

- They are decision support tools (not transaction systems)
- They can compute plans and schedules for multiple variables and constraints simultaneously.
- They use advanced methods and algorithms to solve optimization problems.
- They provide a very high processing speed.

These characteristics correspond with what is stated by APICS, but are even more focused towards the optimization, as this provides the possibility to plan with multiple variables and utilize a high processing speed.
Several authors emphasize the fact that APS is a decision support system, a computer system designed to assist managers in selecting and evaluating courses of action by providing a logical, usually quantitative, analysis of the relevant factors (APICS, 2008), and stresses that the planners should make the final decisions, as they have insight into the particular supply chain, know about the system constraints and also have a general knowledge about feasibility in the plans that are created (McKay and Wiers, 2003; Rudberg and Thulin, 2009). Planners also do the modelling and make the decisions regarding use of input to the model, for example business rules to guide the planning engine.

The definitions of APS discussed in the previous have led to the following combined definition: APS is a decision support system that uses advanced optimization methods, handles finite resources, includes at least some of the modules from the matrix in Figure 5 and has higher processing speed than traditional ERP systems. Due to the fact that Figure 5 is a well-known illustration of APS, it will be used as an illustrative base in this thesis. This is, apart from being familiar, a structured way of identifying APS, which will serve its purpose well here. The purpose being to identify the scope and focus of the research, but also to compare case descriptions.

2.3.2 Comparing ERP and APS

When discussing and studying APSs a comparison with ERP systems is not unusual. This is not surprising, as APSs are meant to improve the planning within ERP systems, by extracting data from them, making calculations and then returning the data. Lütke Entrup (2005) lists some differences between the planning constituted within traditional ERP and planning with the use of APS (Table 1), which puts focus on what additional functionalities an APS intend to add to the ERP system.

<table>
<thead>
<tr>
<th>Areas</th>
<th>Traditional ERP</th>
<th>APS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning philosophy</td>
<td>Planning without considering the limited availability of key resources required for executing the plans</td>
<td>Planning provides feasible and reasonable plans based on the limited availability of key resources</td>
</tr>
<tr>
<td>Goal: First-cut requirements estimate, feasible plans</td>
<td>Goal: Optimal plans</td>
<td></td>
</tr>
<tr>
<td>Push</td>
<td>Sequential and top-down</td>
<td>Integrated and simultaneous</td>
</tr>
<tr>
<td>Business driver</td>
<td>Manufacturing coordination</td>
<td>Satisfaction of customer demand</td>
</tr>
<tr>
<td>Industry scope</td>
<td>Primarily discrete manufacturing</td>
<td>All industries including process industries</td>
</tr>
<tr>
<td>Major business areas supported</td>
<td>Transaction: Financials, Controlling, Manufacturing, HR</td>
<td>Planning: Demand, Manufacturing, Logistics, Supply Chain</td>
</tr>
<tr>
<td>Information flow</td>
<td>Top down</td>
<td>Bi-direction</td>
</tr>
<tr>
<td>Simulation capabilities</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Ability to optimize cost, price, profit</td>
<td>Not available</td>
<td>Available</td>
</tr>
<tr>
<td>Manufacturing lead-times</td>
<td>Fixed</td>
<td>Flexible</td>
</tr>
<tr>
<td>Incremental planning</td>
<td>Not available</td>
<td>Available</td>
</tr>
<tr>
<td>Speed of (re-) planning</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Data storage for calculations</td>
<td>Database</td>
<td>Memory-resistant</td>
</tr>
</tbody>
</table>

Table 1 Traditional ERP versus APS (Lütke Entrup, 2005)

These proposed differences between traditional ERP and APS are important when trying to get the picture of what APS is. APS is a planning tool and when the complexity of the planning calls for more sophisticated support than what MRP offers, APS is more suited than ERP to handle it. ERP is a transactional system and when it comes to handling transactions within a company it is more suited than APS (which is not able to handle transactions at all). This is an important distinction to make. As the two types of systems are not designed to handle the same processes and problems, they are not
really fit to be compared as in Table 1. Although if the comparison is seen as a way to describe what APS are and which functionality the systems provide, then the table fills its purpose.

The contents of Table 1 needs to be clarified, for instance, the simulation within APS is in most systems what-if analyses, which also is what APICS states about simulation within MRP II (APICS, 2008). This implies that the simulation possibilities should be somewhat similar in ERP and APS, but since APS uses more advanced mathematics and also uses the computers random access memory, which gives faster processing, the capability is probably higher in APS than in ERP. Also, a few APS vendors have incorporated real simulation capabilities in their APS packages which perhaps will be more and more common in the years to come. A question can though be raised concerning the push vs. pull planning philosophies since both can exist in both APSs and ERP systems. This makes this push vs. pull distinction between the different systems too simplified to describe the reality in a good way.

2.3.3 Tactical planning with APS

The tactical (or mid-term) planning level, which is the scope of this thesis, consists of tasks handling capacity, materials, distribution and mid-term sales planning (Figure 4). These tasks are primarily supported by the master planning and demand planning modules, but to some extent also by the demand fulfilment module, which uses the output from the master planning module as a frame when creating order promises (Figure 5). These three modules are described into more detail in the following, starting with the demand planning module.

Forecasting future demand is an important task and the forecast is crucial when conducting supply chain decisions, as they should be based on customer orders and planned sales or forecasts. Consequently, several APS modules use the output from DP as input, for instance the Strategic Network Design module, the Master Planning module and the Production Planning module. On all decision levels there is a need to know the future demand and the purpose of the demand planning is to improve decisions affecting the demand accuracy and calculations of buffers and safety stocks (Wagner, 2008). The DP module in an APS supports the forecasting process mathematically by using several different statistical forecasting methods in different settings. It also supports the use of judgmental (or manual) forecasts, either as forecasting method itself or as a way of adjusting the final forecast to utilize the advantages of both methods. In addition to this, the DP module also supports the method of collaborative forecasts, where input can be collected from all involved departments, including customers, to make sure that as much as possible of the relevant information is used (Lütke Entrup, 2005). This collaboration is also a way to get an organizational agreement regarding the planning result, as it is based on the forecast (ibid.). One of the beneficial functionalities of the DP module is the ability to easily aggregate and disaggregate forecasts based on different customer segments, product groups, time buckets or internal organizational functions. This gives managers and other users an overview of the forecast on whatever dimension and level desired.

The master planning module (MP), or multi-site master planning module as it is sometimes called, supports decisions concerning the planning of capacity in terms of production, distribution or supply across the supply chain. The aim is to synchronize the flow of materials through the supply chain and avoid overloading of bottlenecks and other resources. MP has also the ability to allocate production volumes to different sites in order to even out the loadings and get a better plan. Because of the target of evening out the loadings, it is important that the planning horizon covers at least one seasonal cycle, as the peak season demand must be evened out over the off season (Rohde and Wagner, 2008). The results from MP are used as targets or frames for several other APS modules (or other systems), which are depending on the plan from MP. The data in MP is in an aggregated form, both concerning product groups and concerning time slots, and also, only bottleneck or possible
bottleneck resources are modelled, to decrease the complexity and uncertainty. Because of this it is possible to conduct optimization on the data in MP, which brings the possibility to use different objectives, such as minimizing cost or maximizing revenue or profit (ibid.). This optimization is often based on a mix of internally developed solvers and commercial ones (Lütke Entrup, 2005).

The module called demand fulfilment (DF) supports the allocation of products or resources to incoming customer orders. Basically the demand fulfilment module gets an order request, looks for available products or production capacity, if found it allocates this to the order and returns a delivery promise. This question, concerning giving accurate order promises is one of the most important issues for companies with order driven production. It has also been shown to be one of the main reasons for companies to implement APS (Gruat La Forme et al., 2009). The achievement of more accurate order promises is dependent on how the company succeed in aligning their order promising and planning processes with the actual production constraints facing them. These production constraints are either related to the availability of material (raw material, modules, finished goods, etc.) or to the availability of production capacity. The quoting of materials is labelled Available-to-promise and the quoting of production capacity is labelled Capable-to-promise. Traditionally, if material has not been available, the order promising has been based on the planned production lead time (Kilger and Meyr, 2008). Today this is not sufficient if the company wants to keep up with the competition, which Bixby et al. (2006) also describe. Modern APS based solutions offer these more sophisticated CTP solutions which use accepted orders, production capacity and forecasts to calculate a more realistic delivery date. These solutions aims at improving the on-time-delivery by generating reliable quotes, reducing the number of missed business opportunities by searching more effectively for a feasible quote and increasing revenue and profitability by offering less discounts due to high inventory levels and hence increasing the average sales price (Kilger and Meyr, 2008). In the process of quoting order promises, some companies have to choose between orders, as they don’t have the capacity to fulfil all demand. By introducing customer segmentation in this process, the utilization of the resources can be primarily reserved for high prioritized customers and hence the company rejects some order requests. The use of revenue based management in this process gives an opportunity to keep the overall profitability in focus (Kirche and Srivastava, 2003). Bixby et al. (2006) found that the CTP application improved the on time delivery most during periods with high demand. This led to the conclusion that the system is most helpful when the demand and the business complexity increase, which also is an intuitive conclusion.

2.4 The use of Advanced Planning Systems

The important area for APS is the industrial setting, where the systems are meant to serve as enablers for more effective planning. In spite of this, there are not that many cases describing the implementation aspects and use of APS (Wiers, 2009). As an indicator, a simple search on Scopus for “Advanced Planning Systems” or “Advanced Planning and Scheduling” combined with “case study” returns 26 articles. A search for “Enterprise Resource Planning” and “case study” returns 548 articles. This also indicates what Wiers stated, that there is quite a big gap to fill in describing real life situations where an APS is concerned.

In the beginning of the research leading to this thesis a study was conducted with focus on examining the market for APS in Sweden, from the vendors point of view (Cederborg and Kjellsdotter, 2007). The study focuses on commercial off the shelf APS and is based on interviews with vendors and consultants acting on the Swedish market. It is presented in an abridged version here:

The vendor selection for the study was based on practical issues, meaning that the authors were trying to get in touch with every APS vendor they heard about, asking for an interview. Also the annual Plan conference in Stockholm 2007 was used to get in touch with vendors. Vendors that for some reason wouldn’t agree to an interview or, as one vendor, wanted sole right to the study, were
excluded. The studied APS vendors were: i2 Technologies, IFS, Lawson, Oracle, SAP, Syncron and Zemeter. In retrospect it has been shown that ComActivity and IBS, two companies that were included in the study, should have been excluded as their systems do not have the characteristics to make them classified as APSs. Because of this they are not included in this abridged version.

In the literature a number of selection criteria have been suggested to obtain an objective and structured comparison between different software vendors. Stadtler and Kilger (2005) use several selection criteria when discussing the selection process of an APS. Furthermore, Shehab et al (2004) have in a comprehensive review of research literature from 1990 to 2003 identified 29 different ERP selection criteria. It is of interest to examine some of these criteria and how vendors on the Swedish market response to them. The criteria investigated here are divided into three groups, functional criteria, vendor specific criteria and the user situation. Functional criteria are about the application, the vendor specific criteria submit to the APS vendor, and the user situation refers to how the system appears from the user’s perspective.

The functional criteria are partly based on the supply chain planning matrix (Figure 4), which considers planning horizon and planning processes and is useful when studying if and how different APS differ in the context of supported planning processes. The matrix and the ways the processes are supported by different APS are therefore of utmost interest when choosing a system to fit a specific company’s unique requests. The nine APS modules that support the processes in the matrix (Figure 5) are therefore listed for each vendor. Another thing to pay attention to when studying APS is what optimization possibilities the system offers. Some systems use commercial optimization software, others use proprietary tools to solve more or less complicated optimization problems, such as; cost minimization, lead time minimization or maximization of profit.

In order to derive proper plans it is important to have a strong integration between the APS and the ERP systems. Stadtler and Kilger (2005) explain that the integration approaches for APS range from vendor specific integration techniques to standard middleware systems. An advantage with internal interfaces like the one between SAP R/3 and SAP APO is that it is easy to implement. Although data is transferred relatively easy between R/3 and APO, data provided by external systems requires extra interface programming. This being so, an interesting criterion is if the APS vendor also offers an ERP system. Vendor specific middleware products and standard middleware products are open to other systems but a standard middleware product is supported by a wider range of applications. In addition to the integration technology, it is interesting to investigate the integration mode, which refers to how the data from ERP and other applications is uploaded to the APS. Either online interfaces can be used, which enables continuous update, or batch processing systems, where data is accumulated over a period of time and processed as a single batch (Stair and Reynolds, 2003). In summary the following criteria will be investigated; planning processes covered (shown in Table 2), optimization engine, ERP system available, application integration and integration mode.
Considering the functional criteria, i2 Technologies, Lawson, Oracle and SAP offered all of the planning modules, whereas the other vendors missed at least the Strategic Network Planning, The Distribution Planning and the Transport Planning modules. All vendors use optimization engines, either proprietary or commercial, which also is one of the characteristics of APS. IFS, Lawson, Oracle and SAP all offered complete ERP systems, which i2 Technologies, Syncron and Zemeter did not. When looking at the integration all vendors use some kind of open integration technology, which isn’t surprising since it can be seen as an adaptation to the market needs with multiple systems and multiple vendors. Still some vendors use internal interfaces between their own products, but in those cases they use other techniques to enable integration with other systems. All vendors offered both batch- and online integration mode, since the two modes have different advantages.

Stair and Reynolds (2003) point out the importance of careful investigation of the vendors when choosing a system as it is not only a matter of choosing the best software product but also choosing the right long-term business partner. Criteria such as vendor reputation, financial stability, experiences, number of installations, long term viability, years in the APS market, license fee, and market shares are factors usually brought up in the literature to regard during the vendor evaluation (Shehab et al., 2004). Industry focus and experiences are evaluated in this study with help of the number of installations worldwide in different industry segment. Besides that the company focus is compared, that is if the APS vendors concentrate on small, medium or large companies. Also the number of installations in Sweden is evaluated with the aim of understanding the experiences on the Swedish market. The criteria used to compare the APS vendors are; the industry focus and experiences, number of installation in Sweden, years in the APS market, company focus, and license fee (Table 3).

<table>
<thead>
<tr>
<th>APS modules offered by the different vendors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategic Network Planning</strong></td>
</tr>
<tr>
<td>------------------------------------------</td>
</tr>
<tr>
<td>i2 Technologies</td>
</tr>
<tr>
<td>IFS</td>
</tr>
<tr>
<td>Lawson</td>
</tr>
<tr>
<td>Oracle</td>
</tr>
<tr>
<td>SAP</td>
</tr>
<tr>
<td>Syncron</td>
</tr>
<tr>
<td>Zemeter</td>
</tr>
</tbody>
</table>
Some of the selection criteria identified by Shehab et al. (2004) are the frequency of release updates, user support, the implementation time and user friendliness of the system. Since these criteria state something about the user perspective they are grouped together. It is difficult to say something about the user friendliness of the system, but the user interface could be one factor that has an effect on the user friendliness. Also the client/server architecture will be evaluated. There are in particular two architectures used; the three-tier client/server and/or the four-tier client/server architecture. Three-tier architecture consists of client desktops, application servers and database servers, whereas four-tier architecture also includes a web server located between the client and the application server (Stair and Reynolds, 2003). The criteria investigated under the user perspective are; user interface, architecture used, user support, implementation time and frequency of released updates (Table 4).

### Table 3 Comparison on vendor specific criteria

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Industry focus and experience (number of customers in each sector)</th>
<th>Number of installations in Sweden</th>
<th>Year of APS market entry</th>
<th>Company focus (Small, Medium, Large)</th>
<th>License fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>i2 Technologies</td>
<td>Aero&amp;defence(28), Auto(34), Consumer(115), Energy&amp;chemicals(38), HiTech(123), Logistics(54), Meta(49), Pharm(23)</td>
<td>n/a</td>
<td>1988</td>
<td>L</td>
<td>over average</td>
</tr>
<tr>
<td>IFS</td>
<td>~150 in total, covering: aerospace and defense, automotive, consumer goods, food and beverage, high tech, machinery, retail</td>
<td>n/a</td>
<td>1997</td>
<td>M L</td>
<td>n/a</td>
</tr>
<tr>
<td>Lawson</td>
<td>Distribution(11), Fashion(1), Food&amp;Beverage(56), Mining(1), Manufacturing(22), Retail(2)</td>
<td>100 - 200</td>
<td>1998</td>
<td>M L</td>
<td>middle (based on size and value for customer)</td>
</tr>
<tr>
<td>Oracle</td>
<td>~70 in total, covers more or less all industries</td>
<td>5 - 10</td>
<td>1995</td>
<td>L</td>
<td>over average</td>
</tr>
<tr>
<td>SAP</td>
<td>~1000 in total, covers more or less all industries</td>
<td>10 - 15</td>
<td>1998</td>
<td>L</td>
<td>over average</td>
</tr>
<tr>
<td>Syncron</td>
<td>Aerospace &amp; Defense(1), Automotive(4), Consumer Products(6), Industrial equipment(7), Mining &amp; Construction(5)</td>
<td>~10</td>
<td>2000</td>
<td>L</td>
<td>depends on complexity of products, systems and links in the chain</td>
</tr>
<tr>
<td>Zemeter</td>
<td>Chemical/Petrochemical industries(65), Food/Beverage(29), Semiconductor-Hightech(10)</td>
<td>1</td>
<td>1993</td>
<td>M L</td>
<td>depends on number of modules implemented</td>
</tr>
</tbody>
</table>

---

**Table 3 Comparison on vendor specific criteria**
Both concerning the vendor specific criteria and the user perspective, there are no big differences between the different vendors and systems; they all seem to be somewhat alike. Although there are some differences that can be highlighted. The strategic network planning is a module that is used quite seldom and in strategic projects, which can explain why only four of the seven vendors have that module. Also the distribution planning and transportation planning modules are rare, with a possible explanation that there are several niche vendors who supply this one product only and therefore most likely can make a better adjustment to one or a few segments. Besides that, many companies are outsourcing their transportation planning to logistics providers as Schenker and DHL, which eliminates the need for this module.

When it comes to the vendor specific criteria, there does not seem to be any clear connection between the system most used worldwide and the system most used in Sweden. Lawson is the vendor that has the highest number of installations in Sweden, which could be explained by the fact that the ERP system Movex is widely used in Sweden. The majority of the vendors concentrate on larger companies and the reason might be that APS requires a well working ERP system, which larger companies are more likely to have. There seem to be a connection between the license fee and the company focus, where focus on large companies brings a higher license fee. Although, a reservation must be made concerning the price as the license fee depends on the number of modules, number of users, size of the company etc. An APS vendor in the upper layer might in some cases offer a better price than a vendor in the lower price sector.

Considering the user perspective, implementation times estimated by the vendors are similar, yet one should remember that the times given are direct information from consultants and vendors, not actual implementations. When it comes to the architecture most vendors supply the customer with a web server solution, which makes the system more flexible since it can be reached from anywhere.

The seven systems compared are similar in many aspects, for examples all use open technology to integrate with other systems, online data transfer technique and user friendly interfaces. Most vendors concentrate on larger companies and offer web server solutions. It has become apparent that ERP systems many times contain much of the same functionality that APS. The problem often refers back to where to draw the line between the APS and the ERP system. Many ERP systems nowadays use finite capacity and material constraints, some simulation capability and more advanced mathematical algorithms. The more used a module will be, the more likely it is to be incorporated in tomorrow’s ERP systems. On the other hand ERP is still a transactional system and

<table>
<thead>
<tr>
<th>Vendor</th>
<th>User Interface</th>
<th>Client/Server</th>
<th>User Support</th>
<th>Implementation Time</th>
<th>Frequency of Release</th>
</tr>
</thead>
<tbody>
<tr>
<td>i2 Technologies</td>
<td>Microsoft Windows alike</td>
<td>4-tier</td>
<td>Depends on the contract</td>
<td>n/a</td>
<td>1-2 releases per year</td>
</tr>
<tr>
<td>IFS</td>
<td>Microsoft Windows alike</td>
<td>4-tier</td>
<td>Depends on the contract</td>
<td>3 - 12 months</td>
<td>1-2 releases per year</td>
</tr>
<tr>
<td>Lawson</td>
<td>Microsoft Windows alike</td>
<td>3-tier</td>
<td>Depends on the contract</td>
<td>2 - 6 months</td>
<td>1-2 releases per year</td>
</tr>
<tr>
<td>Oracle</td>
<td>Microsoft Windows alike</td>
<td>4-tier</td>
<td>Depends on the contract</td>
<td>3 - 12 months</td>
<td>1 release per year</td>
</tr>
<tr>
<td>SAP</td>
<td>Microsoft Windows alike</td>
<td>4-tier</td>
<td>Depends on the contract</td>
<td>n/a</td>
<td>1 release every 2nd year</td>
</tr>
<tr>
<td>Syncron</td>
<td>n/a</td>
<td>4-tier</td>
<td>Depends on the contract</td>
<td>~6 months</td>
<td>3 releases per year</td>
</tr>
<tr>
<td>Zemeter</td>
<td>Microsoft Windows alike</td>
<td>4-tier</td>
<td>Depends on the contract</td>
<td>~3 months</td>
<td>1-2 releases per year</td>
</tr>
</tbody>
</table>

Table 4 Comparison between systems regarding the user perspective
does not have the ability to support planning as an APS; this is in particular true for the modules at strategic and tactical level. In theory APS also produce plans faster, as the data is processed in the computer’s memory alone, and optimal plans as optimization tools are used.

2.5 Implementing APS

One goal of any organisation’s decision to change a system is of course a successful implementation of the new system. When changes involve several functional areas in the supply chain, the possibility of failure increase (Wetterauer and Meyr, 2008). Compared to an ERP implementation, which is a huge process (Bingi et al., 1999) an APS implementation is usually a lot smaller and hence a lot simpler. Cultural differences between APS and ERP concerning implementation methods, documentation and process descriptions also exist according to Wiers (2002). The difference is that the ERP implementation is a much more structured process than the APS implementation, which is more ad-hoc based. Having an ad-hoc based implementation process is contrary to what is suggested by literature, where many authors emphasize the need for a structured APS implementation process (Kilger, 2008; Lütke Entrup, 2005; Wetterauer and Meyr, 2008).

As described in the previous chapter, the normal implementation time, according to APS vendors, ranges from a few months to a year (Cederborg and Kjellsdotter, 2007), but the implementation time strongly depends on the size of the project. In an APS project, three distinct phases can be distinguished; the evaluation phase, the selection phase and the introduction phase (Wetterauer and Meyr, 2008). The evaluation phase should result in a concept for the company’s future planning tasks and processes, independent of what APS that might be selected or if any system at all should be selected. The selection phase is crucial, since it is at this point the choice of system is to be made. The market needs to be carefully examined and systems need to be compared. In this phase some of the criteria presented in the previous chapter (Cederborg and Kjellsdotter, 2007) could be of use to distinguish special characteristics of vendors and systems. The last phase, the introduction phase, is the phase where the modelling takes place. The models must be developed to support all of the planning tasks to be included at the company (see Figure 4 for example of planning tasks). In this phase there is a need for experienced modellers, as APS tools can be insufficient in supporting the modelling process (Zoryk-Schalla et al., 2004). Also, Zoryk-Shalla et al. reported on identifying many difficulties during the implementation process, which could be directly linked to errors in the modelling process. Another crucial issue in the introduction phase is the pre-implementation testing, both concerning the integrity of data, the communication between models and the question of response time (Bixby et al., 2006). This is also a conclusion by Kilger (2008), who found that the batch interface was easy to implement, but the online integration wasn’t, as the demand for updated and correct data became a problem.

The three described phases put focus on pre-implementation issues, to stress how important these are. Also, Wetterauer and Meyr (2008) emphasize the importance of monitoring and controlling the project, for instance with use of KPIs measuring factors such as delivery performance, supply chain responsiveness, inventories and cost.

2.5.1 Effects achieved with APS

Considering the effects of ERP, Olhager and Selldin (2003) find that ERP implementations usually don’t have that much effect on the inventory levels, on-time delivery or operating costs. They instead point at other areas where ERP systems are beneficial, such as the availability of information, the process integration and the information quality. Also, when asking about the future plans for extending their ERP system, they find that about five per cent already had an APS module implemented and 45 per cent of the companies were planning, or considering, extending their
system with an APS module. Any company that considers extending their system with an APS module would naturally expect to gain from it. Although few (Wiers, 2009; Rudberg and Thulin, 2009), there are articles where the use of and the achieved benefits from APS have been presented and discussed (some of these are presented in Table 5).

Table 5 APS effects with references (Cederborg, 2010)

<table>
<thead>
<tr>
<th>Intangibles</th>
<th>Tangibles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved on-time-delivery</td>
<td>*</td>
</tr>
<tr>
<td>Increased planning (and replanning) speed</td>
<td>*</td>
</tr>
<tr>
<td>Reduced inventory levels</td>
<td>*</td>
</tr>
<tr>
<td>Increased customer service level</td>
<td>*</td>
</tr>
<tr>
<td>Reduced total cost</td>
<td>*</td>
</tr>
<tr>
<td>Improved forecast accuracy</td>
<td>*</td>
</tr>
<tr>
<td>Increased average sales price</td>
<td>*</td>
</tr>
<tr>
<td>Less emergency transports between DC:s</td>
<td>*</td>
</tr>
<tr>
<td>Reduced overtime in production</td>
<td>*</td>
</tr>
<tr>
<td>More synchronized production and demand</td>
<td>*</td>
</tr>
<tr>
<td>More optimized production mix with regard to resources</td>
<td>*</td>
</tr>
<tr>
<td>More stable system with less IT problems</td>
<td>*</td>
</tr>
<tr>
<td>Reduced non value added activities in production</td>
<td>*</td>
</tr>
<tr>
<td>Real time overview of the Supply Chain</td>
<td>*</td>
</tr>
</tbody>
</table>

The most common effect found is reduced inventory level, which isn’t surprising, since inventory is easy to measure and compare. Also, inventory is a way of securing supply, either for customers or for internal processes (Krajewski et al., 2007) and as the planning gets more reliable, the need for extra safety decrease. Another common effect from APS is improved on time delivery, which is tightly connected to the use of demand fulfilment and CTP (Tinham, 2006; Kilger and Meyr, 2008; Schultz, 2002; Gruat La Forme et al., 2009), as the demand fulfilment module decides the delivery time for an order and hence will improve this if functional. The improved forecast accuracy seen in several APS cases is as much a result of the implemented system as it is a result of the new processes implemented because of the new system (Gruat La Forme et al., 2009; Kilger, 2008; Bixby et al., 2006). The need for effective processes around the APS is also emphasized by Jonsson et al. (2007), when they study three companies using APS. They conclude that it is most likely that to achieve real effects from APS there is a need for a proper planning organization and a companywide commitment to the plan. One thing that Kilger (2008) concludes is that the benefits described in that case were realised through the assignment of each major KPI to one responsible manager. This also facilitated the continuing development of processes affecting the KPIs in question.

When studying published literature concerning effects of APS implementations there are several accounts on observed effects, as just described. But when it comes to how to achieve these effects there is a gap in the literature. Published articles mostly concern case studies on one or a few companies with a good experience from APS systems, so called success stories. From these case studies the effects in Table 5 have been derived, as it gives an indication of effects that could be achieved with an APS in the best case. But how should a company act to be able to achieve these
effects. The answer to that question can be labelled critical success factors (CSFs), which states what areas to put focus on to achieve success.

2.5.2 Factors effecting the results of APS implementations

In literature there are, to the author’s knowledge, no accounts on CSFs concerning APS implementations. Because of this the literature on ERP CSFs has been studied. The implementation of an ERP system is a complex process that affects an entire company (Davenport, 1998). An APS is a decision support system that, in most cases, adds functionality to an ERP system, as it extracts, treats and returns data to the ERP system. Still, many IT systems implementations present similarities, which is why this research is studying ERP CSFs and their applicability in APS implementations.

Several authors have published studies on ERP CSFs and they have all come to more or less the same result in the sense that the factors they have derived are similar. Dezdar and Sulaiman (2009) and Ngai et al. (2008) are two recent literature reviews on ERP CSFs, which have studied published articles and come to similar conclusions concerning CSFs for ERP implementations. Grabski and Leech (2007) have derived CSFs from a survey and have also concluded that there is interaction between the groups of factors, meaning that a company needed more or less all of them to be successful. Other published studies concerning ERP CSFs have also come to the same conclusions. A comparison between two CSF settings is shown in Table 6, where the factors are structured in a way that makes the similarities between the studies apparent.

<table>
<thead>
<tr>
<th>Category</th>
<th>CSF (Dezdar and Sulaiman)</th>
<th>CSF (Ngai et al.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP technology</td>
<td>Careful selection of ERP software</td>
<td>Fit between ERP and business/process</td>
</tr>
<tr>
<td></td>
<td>Software analysis, testing and troubleshooting</td>
<td>Software development, testing and troubleshooting</td>
</tr>
<tr>
<td></td>
<td>System quality</td>
<td>Country related functional requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Data management</td>
</tr>
<tr>
<td>External expertise</td>
<td>Vendor support</td>
<td>ERP vendor</td>
</tr>
<tr>
<td></td>
<td>Use of consultant</td>
<td></td>
</tr>
<tr>
<td>ERP user</td>
<td>User training and education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>User involvement</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>Top management support and commitment</td>
<td>Top management support</td>
</tr>
<tr>
<td></td>
<td>Enterprise-wide communication and cooperation</td>
<td>Communication</td>
</tr>
<tr>
<td></td>
<td>Business plan and vision</td>
<td>Business plan/vision/goals/justification</td>
</tr>
<tr>
<td></td>
<td>Organizational culture</td>
<td>Organizational characteristics</td>
</tr>
<tr>
<td></td>
<td>Appropriate business and IT legacy systems</td>
<td>Appropriate business and IT legacy systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National culture</td>
</tr>
<tr>
<td>ERP project</td>
<td>Project management and evaluation</td>
<td>Project management</td>
</tr>
<tr>
<td></td>
<td>Business process reengineering and minimum customization</td>
<td>Business process reengineering</td>
</tr>
<tr>
<td></td>
<td>Change management programme</td>
<td>Change management culture and programme</td>
</tr>
<tr>
<td></td>
<td>ERP team composition, competence and compensation</td>
<td>ERP teamwork and composition</td>
</tr>
<tr>
<td></td>
<td>Project champion</td>
<td>Project champion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monitoring and evaluation of performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ERP strategy and implementation methodology</td>
</tr>
</tbody>
</table>

Table 6 Comparison between two settings of ERP CSFs


3 Methodology

In this chapter, the methodology applied in this research and the research process is presented. Discussions are also made regarding the validity and reliability of the research and the results.

3.1 Research process

The research behind this thesis is part of a project named ISCAPS, which is short for “Integrating the supply chain employing advanced planning systems”. This project is a collaboration between Linköping University and Chalmers University of Technology, with one Ph.D. candidate and one senior researcher at each university. The project is financed by Vinnova, which is the Swedish governmental agency for innovation systems. Also, three consultant firms have supported the project in kind, mainly by providing information on APS and suitable case companies to contact.

Initially in the ISCAPS project, before the research papers presented in this thesis, the study presented in chapter 2.4 was conducted with the aim to explore the Swedish market for APS and to get a better understanding of the systems in question (Cederborg and Kjellsdotter, 2007). In this study several APS and ERP vendors were interviewed, to get their view of the current state. This study worked as a catalyst for further research, as it helped derive interesting questions and create a theoretical base within the project. One of the conclusions made were that APS might be more beneficial at tactical and strategic planning levels, where the optimization engine is used.

The structure of the research is first to focus on one case where the situation is studied into detail. The latter part of the research is focusing on the actual performance of these systems; a multiple case study is conducted to search for similarities and differences among the studied companies and their experiences from APS. The focus of this research has been to explain and understand APS. The reason for choosing case studies is that the strategy suits well when working with this kind of research (Yin, 2003). In addition to this, the first two parts of the research did require recurrent interviews, as the information gathered each time led to a deeper understanding, which in turn led to several new questions. Also, the need for diversified data collections demanded interviews to be conducted with several persons. The choice of a multiple case study in the second part of the research was a more difficult decision. Here there was also a possibility to conduct a survey. The major issue pointing towards case studies was the possible need to ask deepening questions and have a discussion with the interviewee about definitions. This, in combination with the fact that the industrial use of APS at the tactical planning level is scarce, makes it very difficult to design and conduct a survey with valid results. Also, when seeking information from managers, Stuart et al. (2002) emphasizes that interviews without highly structured formats or strict adherence to prepared questions may sometimes be the one way to get the best available information. In accordance to this, all interviews in the study behind this thesis have been semi structured, with the interviewer using a structured interview guide to make sure that all topics are covered.

3.2 Research design

The research design is based on the five research questions (chapter 1.3). The first study was designed to help answer the first three questions, namely how the use of APS affects the DP, MP and DF processes respectively. The second study was meant to answer the third research question, just focusing on the DF process. When conducting these two studies evidence on results from APS implementations were discovered, which made them contribute to the fourth research question also. The third study was designed to answer the last two research questions, focusing on effects from APS and how to achieve these effects. This is visualised in Figure 6.
Throughout the entire research process, literature studies have been conducted, as shown in the research model, Figure 2 chapter 1.3. These have been conducted both in order to find new literature, but also to deepen the knowledge in certain areas connected to APS, such as revenue management. Although this part has been very important in the research process it is not visualized in Figure 6 above.

3.2.1 Case study 1

The first step of the research process behind this thesis was focused on the APS in use at the tactical planning level at SSAB Plate. Here, the research aim was to understand and analyse the system and the use of it in a process industry setting. At SSAB plate, several interviews were conducted, with people in different positions, both users of the APS, people involved in the implementation and people who worked in the surrounding areas, meaning that they either provided input to or used the results from the APS. In addition to this, internal documentations were studied and meetings were attended, all to get a comprehensive view of the studied system and also to validate the information given. This first study led to research paper one, but the information gathered was also used in the second research paper, as they concern the same company and hence it is impossible to separate the knowledge gathered in the first study from the second.

3.2.2 Case study 2

In the second study the purpose was to examine the use of APS in the demand fulfilment process more into detail to answer the third research question concerning DF. Data gathered in the first study was even used here, as the first study had provided more in depth knowledge about the demand fulfilment than what was needed in that study. In addition to this, interviews were conducted with about the same selection of people as in the first study, internal documentation was studied and meetings concerning the system were attended. Also, the author attended internal training at the company, both to learn about the system, as well as to gather feedback and information from people attending the course. This study led to research paper two, with focus on answering the third research question.
3.2.3 Case study 3

In the third step of the research process, a multiple case study was conducted at four companies that have recently implemented APSs. In this study, the goal was to study what factors during an APS implementation that might affect the results concerning the company as a whole. The initial contact with the four companies was facilitated through one of the consultant firms involved in iSCAPS. This firm has also been the subject of interviews, partly with the purpose to validate the data collected at the companies, as both the consultants and the companies should provide comparable answers. The third case study have led to research paper three, which have had the goal of answering the last two research questions.

3.3 Research quality

In this chapter the quality of the research is discussed in terms of validity and reliability.

3.3.1 Validity

The quality of social studies, in which case studies are a part, is often examined with four tests; construct validity, internal validity, external validity and reliability (Yin, 2003). This chapter addresses these tests one by one, trying to address and explain the intentions and actions of the researcher.

Construct validity concerns using the correct measures to measure the phenomena it is supposed to (Stuart et al., 2002). To ensure this, Yin (2003) suggests the following tactics:

- Use multiple source of evidence
- Establish chain of evidence
- Have key informants review draft case study report

In this research multiple sources have been used frequently, in the first two studies several people were interviewed at the same company and internal documentation was studied. In the third study managers at the five studied companies and the consultant company was interviewed, with the responses compared to ensure that correct data had been gathered. In the multiple case study, the interviews were also recorded, to decrease the risk of missing any important information. Also, in the multiple case study, drafts were sent to the interviewees after interviews, to minimize the risk of misinterpretations. In the first two studies validation of the data was done on continuing meetings and by having managers at the company read and comment the research several times during the process. The researcher has also done his best to make sure that the chain of evidence is kept, as it should be possible to trace the results backwards through the process.

Internal validity mainly concern explanatory studies (Yin, 2003) and focuses on the fact that studied relationships are explained by the factors studied and not by other, unknown factors. In the conduction of the multiple case studies, the researcher has tried to uphold the internal validity as to including companies in the study which are much diversified and comparing them with regard to the outcome.

The external validity test is concerned with whether the results from the study can be generalized and applied in other cases. According to Yin (2003) the tactics to use to ensure the external validity is to use theory in single case studies and to use replication logic in multiple case studies. The theory used in all studies is suggesting that the results could be generalized. The key issue when generalizing is to understand to what extent the generalization is possible. Concerning the practical use of the
results, any company will need to look to their own structure when deciding if any results could be applied to them. The theoretical contribution is ensured by use of known theory, as this is in accordance with the results gained from the three studies.

3.3.2 Reliability

Reliability means a way to ensure that the results could be replicated. The recordings from interviews and the documentation ensure that the data can be accessed again. But to ensure that another researcher gathers the same data is more risky, since the researcher plays a big role in semi-structured interviews. Here, the ability to get the interviewee to feel comfortable and to get her or him to discuss the interesting issues is of utmost importance. There is no possibility to guarantee this, but under the assumption that the researcher in question uses the same structured interview guide the results would most likely be the same.
4 Summary of appended papers

A summary of each of the three papers appended in this thesis are presented in this chapter, with the author’s contribution to each paper presented in Table 7.

<table>
<thead>
<tr>
<th>Paper</th>
<th>First author</th>
<th>Second author</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ola Cederborg</td>
<td>Martin Rudberg</td>
<td>The planning and analysis has been equally shared among the authors. The data collection has been shared among the authors. The second author has taken more responsibility in finishing the paper.</td>
</tr>
<tr>
<td>2</td>
<td>Ola Cederborg</td>
<td>Martin Rudberg</td>
<td>The planning and analysis has been equally shared among the authors. The data collection has mostly been the responsibility of the first author. The first author has taken more responsibility in finishing the paper.</td>
</tr>
<tr>
<td>3</td>
<td>Ola Cederborg</td>
<td>Sole author</td>
<td>The planning and analysis has been equally shared among the authors. The data collection has mostly been the responsibility of the first author. The first author has taken more responsibility in finishing the paper.</td>
</tr>
</tbody>
</table>

Table 7 Author’s responsibility for the appended papers

4.1 Paper 1 – APS for Tactical Planning in a Steel Processing Company

This paper puts focus on describing the use of an APS in a steel processing company and comparing the situation before and after the implementation of the APS. The purpose of the paper is to describe and analyse the impact of the implementation of APS at the tactical planning level. A case study is conducted at a typical steel processing company, with a demand that widely exceeds the production resources, which makes capacity constrained planning crucial. The company implemented an APS suite consisting of Demand Planning, Demand Fulfilment and Master Planning and in the process they also centralized the previously diversified master planning.

The findings in this paper imply that the implementation of an APS is mutually dependent on changes in the planning processes. The study shows several positive results for the company as a result of the implementation. The demand planning improved with a more standardized and streamlined process and more reliable forecasts. The master planning, with the introduction of the supply chain planner as decision support, made the company achieve a structured planning process with the aim to maximize throughput in bottlenecks. At the same time, they achieved a higher planning accuracy. The demand fulfilment became an automated process with CTP functionality, which made the process much faster and smoother. It also helped to increase the on time delivery by keeping that KPI on a stable level at the same time that the demand almost doubled.

The improvements made cannot entirely be contributed to the APS, the change of processes and the reorganization of the planning function also affected the company’s performance. In spite of this, the changes were crucial for effective utilization of the APS, and the APS can be seen as an enabler for them. Problems that were experienced with the APS were mostly personnel related, such as not enough training or not enough time to actually use the system.

4.2 Paper 2 – Capable-To-Promise for Segmented Customers in a Capacity Constrained Manufacturing Environment

This paper concentrates on the demand fulfilment process where the CTP functionality in an APS is used in a process industry setting. In this setting customer segmentation is used to prioritize between orders, as the production capacity does not allow all order requests to be accepted.
The purpose of the second paper is to analyse the use of APS in a demand fulfilment process, with focus on CTP functionality concerning segmented customers. The aim is to first describe theoretical effects that can be expected and then contrast these effects with a case study. The effects found to stem from the demand fulfilment module are:

- Improved on-time-delivery
- Reduced inventory levels
- Increased customer service level
- Reduced total cost
- Increased average sales price
- Production more synchronized with demand
- More optimized product mix with regard to resources

The use of an APS in the demand fulfilment process is, according to the company, a satisfactory solution. Of the expected effects derived from literature, the company has seen positive changes concerning the synchronization of product mix and resources, the utilization of production resources and the on time delivery. This has also led to an increase in the customer service level. They have also experienced that the time for returning a delivery promise have decreased. The setting chosen by the company concerning prioritizing customers makes sure that highly prioritized customers almost always get the orders they request, at the expense of lower prioritized customers.

4.3 Paper 3 – Assessing factors affecting results of APS implementations

This paper focuses on examining critical success factors during APS implementations in five Nordic companies. The purpose of the third paper is to find out if ERP success factors are applicable in APS implementations.

The ERP CSFs found in literature are:

- APS technology
  - Country related functional requirements
  - Data management
  - Fit between APS and business/process
    - Software development, testing and troubleshooting
- External expertise
  - APS vendor and consultant
- Organization
  - Appropriate business and IT legacy systems
  - Business plan/vision/goals/justification
  - Communication
  - National culture
  - Organizational characteristics
  - Top management support
- APS project
  - APS strategy and implementation methodology
  - APS teamwork and composition
  - Business process reengineering
  - Change management culture and programme
  - Monitoring and evaluation of performance
  - Project champion
  - Project management
In this study there are indications that some of the critical success factors observed during ERP implementation also are valid during APS implementations. This as the cases studied proved to have more positive effects from their implementations of APSs if they had a better fulfilment of the CSFs. The factors that are found important are appropriate business and legacy system, fit between APS and business/process, top management support and project champion.

Also, the study finds that the use of structured goals and monitoring of effects related to the APS implementation is lacking at many companies.
5 Results

During the research behind this thesis the researcher has had the privilege to study several companies and their APS implementation. This has, apart from what is explicitly written in this thesis, given insight in both the systems as such, but also the work and communication that is needed to get an APS to work properly. In the following a discussion on the overall results stemming from this research is presented. Also, the connections to the research questions presented in chapter 1.3 are clarified.

5.1 APS in the tactical planning process

The first three research questions focus on the effects of APSs on the tactical planning process as such. The questions are separated to handle the processes covered by the three APS modules DP, MP and DF respectively.

5.1.1 (RQ1) How does the use of an APS affect the Demand Planning process?

The question of how APSs affect the demand planning process is primarily covered in paper one but, in addition to this, the third research paper gives some indications to how the companies’ demand planning processes were constituted before the implementation of their APSs, compared to how their processes are structured after.

The process of planning demand has in most cases been manual and quite unstructured before the implementation of an APS. As an APS will not be functional without a structured process, companies need to incorporate new demand planning processes as part of their APS implementations (Wagner, 2008). At SSAB this showed to be an effort taking process, as there was resistance to the new system at first, which also is reported in a study by Wiers (2009). At SSAB this also resulted in the unwillingness to incorporate statistical forecasts in the demand planning process, as this would have been yet another change and hence a reason for disapproval of the APS. Because of this, the forecasting is still done by the sellers, without the aid of statistical methods. This is a way to avoid some conflicts, but at the same time it is a way to avoid the possible improvement in forecasting quality that statistical methods could provide. The forecasting should be based on the best possible information, which is a combination of the sellers and the historical data.

There are indications that APS can facilitate changes in the planning processes in general and hence work as a catalyst for these changes, which can explain that companies are experiencing more streamlined processes after APS implementations. The demand planning in APS has far-reaching functionality for aggregating and disaggregating the forecasted demand in any dimensions incorporated in the system (ibid.). This gives a visibility and overview of both the forecasts and the actual sales in a structured way, which is very useful for managers, as the case at SSAB has shown.

5.1.2 (RQ2) How does the use of an APS affect the Master Planning process?

The second research question is focusing on how APS affect the master planning process, which is primarily covered in research paper one, but also in paper three.

Compared to the demand planning process, the changes to the master planning process have a much more technical complexity, the master planning in APSs makes it possible to use different objectives and utilize the optimization to optimize the plans with respect to these objectives (Rohde and Wagner, 2008). At SSAB the objective function is profit maximization, which is an interesting phenomenon, as most companies use cost minimization as objective function.
Concerning the modelling of the master planning process in APSs, there are needs for experienced modellers, as the planning of complex models will be a lot more time consuming (Zoryk-Schalla, 2001), as have been shown at SSAB. The APS has also been identified as an enabler to help automate the master planning process, centralize it and make it a visible process with a clear focus. It can be argued that the APS has helped SSAB to get a clear objective in their master planning, which in their case is to maximize the throughput in bottlenecks. In the multiple case study it was found that the APS facilitated the centralization of the master planning process, which is a step on the way to a more holistic view of the supply chain planning.

5.1.3 (RQ3) How does the use of an APS affect the Demand Fulfilment process?

Research question three takes the effect of APSs on the demand fulfilment process in focus. This question is discussed in papers one and two.

An APS used in the demand fulfilment process helps to decide possible delivery dates for orders. This is done by utilizing the constrained plan created in the master planning process (Kilger and Meyr, 2008). This means that a company might need to turn down orders, as the delivery date suggested by DF is too far into the future. The delivery date at SSAB is returned within minutes, which is a big improvement for them, especially since the date suggested is based on the actual situation at the company, not on seldom updated lists, as the situation was before. This forces the company to keep within their production capacity limits when booking orders, which wasn’t done prior to the APS. Findings by Bixby et al (2006) show the possibility to reduce the time for returning a delivery promise even more, but this has not been a prioritized issue at the company. Another change in the process is the use of customer priorities, which is supported by the APS modules and has been shown to increase profits also in manufacturing companies (Meyr, 2009). This gives the opportunity to utilize customer priorities to ensure that prioritized customers are not turned down.

Focusing on the perceived effects from the changes to this process, SSAB have a more efficient product mix and utilize their production resources better. Their on-time-delivery has been affected in a positive way and they give their customers more accurate delivery promises.

5.2 Effects of implementing and using an APS

The final two research questions are concerned with effects from implementation and use of APSs. The effects and how to achieve them are in focus for this part of the research.

5.2.1 (RQ4) What effects can be expected from APS implementations?

The fourth research question to be answered is: what effects can be expected from APS implementations. This is primarily dealt with in paper 3, but the other two papers also have findings that help to answer this question.

In the theoretical studies, several effects of APS implementations were found (Table 8). Apart from the increase of sales price, the decrease of emergency transports between DC and the more stable system, all effects found in theory were also identified at at least one of the studied cases. The three that were not identified were in literature found and described in special situations and they cannot be expected at any company starting to use APS. There were difficulties in finding KPIs, since the studied companies did not follow up on the APS projects that well, but although they do not have specific figures, they still have a general opinion about what their APSs have resulted in. The effects can be divided into two groups, tangibles (performance indicators) and intangibles (experiences).
5.2.2 (RQ5) How can a company achieve the effects from an APS implementation?

Concerning the question of how a company can achieve effects from an APS implementation, this research have put focus on examining critical success factors in ERP implementations, to study if they are applicable even in APS implementations. These are studied in paper three.

The CSFs studied were derived from ERP literature, but as such, many of them are valid for any system implementation (Hammant, 1997). Because of this it is not surprising that some of these factors seem to be critical even in APS implementations. There seem to be a connection between having good effects and having several CSFs. The four CSFs that seem to be most important is; appropriate business and legacy system, fit between APS and business/process, project champion and top management support. The first two factors are needed to get the system to fit into the company, which is a logical deduction. If the systems are not appropriate, there will be problems, and if the APS don’t fit the business or the processes, either the APS or the processes need to change. The other two factors are not as obvious, but can probably be linked to the fact that to make use of an APS there need to be an agreement and an acceptance of the plans and the system throughout the company, which also has been shown by Kjellsdotter Ivert (2009). A way to facilitate this is someone who promotes the system, namely a project champion or the top management.

Table 8 Effects found at companies using APS

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</thead>
<tbody>
<tr>
<td>Improved on-time-delivery</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increased planning (and replanning) speed</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Reduced inventory levels</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<td>1</td>
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<td>0</td>
</tr>
<tr>
<td>Increased customer service level</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Reduced total cost</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Improved forecast accuracy</td>
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<td>•</td>
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<td>•</td>
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<td>0</td>
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<tr>
<td>Increased average sales price</td>
<td>•</td>
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<td>•</td>
<td>•</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Less emergency transports between DC’s</td>
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<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>0</td>
<td>0</td>
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| Intangibles | More synchronized production and demand | • | • | • | • |
| Intangibles | More optimized product mix with regard to resources | • |
| Intangibles | More stable system with less IT problems | • |
| Intangibles | Reduced non value added activities in production | • | • |
| Intangibles | Real time overview of the Supply Chain | • |

By implementing an APS a company can hence have expectations on the benefits above, as those are shown to be quite common results (see references in paper 3). But the companies need to remember that not all implementations are successful and it is not all that uncommon with disappointing results and implementation failures.
5.3 Discussion and concluding remarks

The overall purpose of this research has been to find out if and how APS can support the tactical planning processes and add value to the company. The results found in this thesis indicates that APS can act as a catalyst for improving the supply chain performance and support the tactical planning processes by adding value to the company. The combined effort of the APS and process changes have created several positive effects for some of the companies studied and there are no indications to the opposite, that APS could not support the tactical planning process. Although there are indications that APS can be a more effort taking task to implement and use, than what the general opinion seem to be, companies that have undertaken these efforts have gained from them, which also supports the conclusion that APSs can support the tactical planning process.

The way in which APSs support the tactical planning processes have been studied and it has been found that the support can be separated in two parts; the support given by the APS and the support given by the process changes made. Findings have also shown that the process changes probably couldn’t have been achieved without the APS, as the implementation of an APS require the change of some processes. Which of these two parts that lead to the realization of effects is hard to distinguish. But as neither of the two parts can be isolated from the other (concerning APSs), companies who want to implement an APS will inevitably need to change some of their processes as well.

This thesis has also contributed with increased knowledge of the use of APSs in process industry companies, as in total five process industry companies have been studied and described. The broadening of the literature base in the area of APSs is an important future task, where this thesis plays a part.

A warning must be raised concerning the generalization of the results, as they stem from only six cases in total. But the results are supported by other researchers published studies, which strengthen them. Considering any single company or organization, they have to study their own special characteristics and situation, to understand if their planning processes could be supported by an APS, but in general it should be so.

5.4 Future research

In order to deepen the knowledge in the area of APSs, the first and most obvious research path is to conduct case studies in the area in order to broaden the literature base. This is needed, which I am not the only one to say, and almost any aspect of industrial use of APSs will contribute to the knowledge base one way or another.

The critical success factors concerning APS implementations and how they in turn affect a company’s performance is another interesting question. This is a difficult task, but the knowledge would provide managers with insights they do not possess today. The major difficulties lie in isolating the factors and effects, to be able to see plausible connections between them.

Another possible research way is to study the parallels with the concept of order qualifiers and order winners (Hill, 2000) and try to distinguish between qualifiers and winners amongst success factors, success qualifiers and success winners. In paper 3 the two system related factors (appropriate business and legacy system and fit between APS and business/process) could possibly be considered qualifiers and the system promoting activities (project champion and top management support) could be considered winners.
References


APS FOR TACTICAL PLANNING IN A STEEL PROCESSING COMPANY

Ola Cederborg and Martin Rudberg*

Department of Management and Engineering
Linköping University
SE-58183 Linköping, Sweden
ola.cederborg@liu.se

Department of Science and Technology
Linköping University
SE-60174 Norrköping, Sweden
martin.rudberg@liu.se

*Corresponding author

Abstract

Purpose:
The main purpose is to describe and analyse the impact that the implementation of an advanced planning system (APS) has on the tactical planning level at a steel processing company. This is done in terms of analysing changes in the tactical planning processes, effects on company performance, and how APS is used in a practical planning context.

Design/methodology/approach:
This research is based on a longitudinal case study in the process industry. The case company, a high-end steel producer, has been studied during several years using a combination of data sources: literature reviews, interviews, archival records, attending meetings, workshops and seminars, etc.

Findings:
This case study points to the fact that implementing an APS and reorganizing the planning department and the planning processes are mutually dependent. The positive effects at the tactical planning level (in terms of service levels, fast and reliable order promises, more accurate forecasts) could not have been realized without the APS. On the other hand, APS could not have been effectively utilized without the organizational change.

Research limitations/implication:
The results presented in this paper are based on a single-case study, but in the context of our literature review and other case studies the findings are still valid and an important step towards better understanding of the practical use of APS.

Practical implications:
The process descriptions, lessons learnt and issues encountered in case studies like this should be helpful to practitioners on their way to implement APS, and companies seeking new ways to improve their planning can use this research to investigate the use of an advanced planning system.

Originality/value:
Studies on the practical use of standard APS software are still scarce. As such this paper provides enhanced knowledge and understanding on the use of APS in an industry setting.

Keywords

Advanced Planning Systems, Demand Planning, Demand Fulfilment, Master Planning, Implementation, Case study
1. Introduction

Increasing pressure on supply chain performance has for many years encouraged companies to take action to improve their overall competitiveness. This pressure stems from increasing customer demands on high quality products at a low price plus higher expectations on accurate deliveries and customer service. Advanced planning systems (APSs) have been put forward as a tool to meet the ever increasing demands on effectiveness that put new pressures on swift and efficient planning and control of the supply chain (David et al., 2006). APS as a commercial off-the-shelf (COTS) decision support system (DSS) for production and distribution planning is still a fairly new and unexplored tool, even though advanced planning and scheduling techniques have been around for more than two decades (McKay and Wiers, 2003). During the last decade, companies that sell enterprise resource planning (ERP) systems have started developing and implementing standard APS-modules, which by the aid of sophisticated mathematical algorithms and optimization functionality, support planning of complex systems such as supply chains (Stadtler and Kilger, 2008; Lin et al. 2007; Wu et al., 2000).

The planning and scheduling task is important for most companies, and planners do need decision support in these areas. A lot of the scientific work on production planning and scheduling in process industries focus on designing dedicated algorithms for a specific situation, or a specific part of the process. However, in practice, companies tend to implement commercially available standard software packages (Wiers, 2002), wherefore there is a need for further analysis of the practical use of these standard systems. Yet, APSs as such, their effects on planning and planning processes, and implementation aspects are largely ignored by academia (Wiers, 2009; Lin et al., 2007; McKay and Wiers, 2003). Wiers (2009) furthermore states that the majority of APS implementations are in the production scheduling domain (operational planning), whereas Gruat La Forme et al. (2009) in their small survey find support for that APS is most common in tactical planning environments. However, there are few accounts on documented studies describing how APS support specific planning processes (Kjellsdotter and Jonsson, 2010), and especially on the practical aspects of APS implementations in the manufacturing industry (Gruat La Forme et al., 2009). The tactical planning is at the centrefold of many companies’ planning processes, and also the planning level where many APS specific features and functionalities (optimization, simulation, capable-to-promise, etc.) are possible to use on a regular basis. Therefore, this study focuses
on the implementation and use of standard APSs for tactical planning in the process industry through a longitudinal case study.

The main purpose of this paper is to describe and analyse the impact that the implementation of three APS modules has had on the case company’s tactical planning. As such, the research questions in this study are the following:

- How have the tactical planning processes changed due to the APS implementation project?
- What effects have the APS implementation project had on the company’s performance?
- What are the advantages and disadvantages with the case company’s way of using the system?

Previous research on the use of APSs is scarce, and case study papers discussing actual APS implementations are crucial to gaining real insight for actual implementations (McKay and Black, 2007). Our case company, SSAB Plate, is the largest Nordic manufacturer of heavy steel plates and has implemented standard APS software for tactical planning. The results are promising, but there is still room for improvements in many areas. For SSAB Plate, capacity constrained planning is of utmost importance, and three APS modules from i2 Technologies have been implemented; demand planner, supply chain planner and demand fulfilment. It has been argued that the promises of APS suppliers are not realized (Fontanella, 2001; McKay and Wiers, 2003), but both the systems and the users have evolved since these studies were carried out. Through this longitudinal case study we hope to increase the knowledge and understanding of the practical use of a COTS APS, and also how APSs can enhance the planning effectiveness for tactical planning in process industries.

The subsequent sections present the methodology and the literature review with a special focus on APSs and supply chain master planning, where after the main part of the paper is devoted to the case study. The case is then analysed and managerial implications are provided before the paper is concluded.

2. Methodology

From a methodological perspective, this research is based on a literature review and a case study. The literature review is founded in the fields of supply chain management, operations management, and advanced planning systems. The case study is based on data gathered
through semi-structured interviews and on-site visits at the plant, as well as on data from the company’s information system database and internal documentation. The authors also had access to primary data in terms of company reports describing processes, performance data, etc. Typically, interviews were carried out with demand planners, master planners, and members of the implementation team. One of the authors also interviewed system users and participated in user training sessions to get a firm understanding of both the system itself and how it is perceived by the users. In this research multiple sources of information have been used frequently. Several people were interviewed and internal documentation was studied. Also representatives from the consultant company were interviewed, with the responses compared to ensure that correct data had been gathered. Also drafts were sent to the interviewees after the interviews, to minimize the risk of misinterpretations. Validation of the data was also done on continuing meetings and by having managers at the company read and comment the research several times during the process. The researchers have also done their best to make sure that the chain of evidence is kept, for instance by ensuring the possibility to trace the results backwards with the aid of the case study protocols.

We have followed the company, its APS use, and its continual enhancement of the system from late 2006 until the beginning of 2010. The case analysis is a comparison between before and after the implementation of the APS suite. This approach is selected in order to capture the results of the APS implementation as well as the changes in working methods and organization, which were a part of the total implementation project. The “before” situation is mainly based on information from interviews and project documentation, since the researchers did not have direct access to the company during this period. The project manager worked at the company before the implementation project was initiated and was a leading person in the software selection process. After the implementation she has managed the planning department and also partly worked as a master planner. She is still at the company but left the planning department in late 2009. The “after” situation is based on how the company was using the APS between 2003 (after the system had been fine tuned) and 2009 (when a new APS upgrade project was initiated). The planning organisation, the planning processes, and the system settings have been fairly intact during this period, but the bulk of data gathering was conducted during 2007 and 2008, wherefore 2007 has been chosen as the reference year for the “after” situation.

Due to the fact that there are few documented cases on the use of standard APSs in tactical planning, this research is of an exploratory nature, which also explains the use of a single-case
study. Yin (2009) lists five rationales for conducting single-case studies, of which two are present in this research: the case is considered typical for its industry segment and the study is longitudinal, revealing the effects of the APS implementation.

3. Advanced Planning Systems

3.1 The APS structure

During the last decade not only APS niche vendors, but also ERP vendors have more aggressively started developing and implementing advanced planning modules, with the aim to support complex planning problems. Nowadays, APS modules are often a part of larger software suites and work as add-ons to existing ERP-systems (Stadtler and Kilger, 2008; Entrup, 2005; Dickersbach, 2004). APSs do not replace ERP; it extracts data from the ERP database, makes its calculations and sends the resulting plans back for distribution and execution. Often, solver engines based on linear programming and mixed integer programming are used to unravel the large amount of data. To cut computing time, heuristics are used built on operations research knowledge (De Kok and Graves, 2003). APSs, consequently, tries to automate and computerize the planning through simulation and optimization. Still the decision-making is done by planners who have insight in the particular supply chain, know about the system constraints and also have a feeling about the feasibility of the plans that are created.

Considering the complex environment that most companies have to cope with, most decision-support systems advocate a hierarchical distribution of the decision-making processes, where the next upper level coordinates each lower level (Stadtler and Kilger, 2008). Strategic decisions (long horizon and long periods) cannot be based on the same level of detail in the information as is the case for operational decisions (short horizon and short periods). Hence, decisions made at a high hierarchical level are normally based on aggregated information (in terms of product families, factories, etc.) and aggregated time periods. Thereafter these high level decisions form the context for the decision-making processes at lower-level decision centres, where decisions are disaggregated into more detailed information and time periods, also the considered horizon is made shorter (Wiers, 2002). Decisions are thus exploded through the hierarchical structure until the lowest level is reached and detailed decisions are executed (cf. Figure 1). One way to classify standard APSs is by categorizing different modules depending on the length of the planning horizon (and thus the level of aggregation)
Figure 1: Planning structure and categorization of typical APS modules (based on Meyr et al., 2005).

3.2 Tactical planning in an APS

Tactical, or mid-term, planning concerns rough quantities of material supplied, workforce requirements, production quantities and seasonal stock and use of distribution channels. To be able to optimize the mid-term supply chain model, production, inventory and distribution must be regarded concurrently. Tactical planning uses data on products and material in aggregated product groups. Inputs are demand data and network constraints in terms of a model that defines capacity and dependencies between different processes. The tactical planning results in a common supply chain plan regarding production, distribution, inventory, procurement and materials requirements (Rohde and Wagner, 2005). This tactical supply chain plan is thereafter on the one hand exploded down the product structure to be used in the detailed planning and scheduling, and on the other hand used as basis for demand fulfilment and order promises. In the context of this study, tactical planning is considered to include demand planning, master planning, and demand fulfilment (cf. Figure 1), which are described in the following.
The demand planning module in an APS does not differ much from good demand planning modules in traditional ERP. The main purpose is of course to improve decisions affecting demand accuracy and the calculation of buffers to reach a predefined service level (Stadtler and Kilger, 2008). Demand planning includes sophisticated statistical forecasting methods, possibilities to aggregate and disaggregate forecast in terms of product groups, geographical regions and time periods in a multi-user environment, and also to establish a consensus-based forecast within the company. The multi-site master planning module with its fairly long planning horizon in most instances needs forecast information to perform the planning task.

In traditional ERP, master planning is often done by infinite MRPII systems (Steger-Jensen and Svensson, 2004), or by simple calculations using spreadsheets without considering capacity limitations (Fleishmann and Meyr, 2003). In an APS, master planning is typically based on linear programming striving to minimize costs (or maximize profit) while meeting demand and taking constraints (e.g. capacity) into consideration as an integrated part of the planning process (Chopra and Meindl, 2004). As such, multi-site master planning aims at synchronizing the flow of materials along the supply chain, and thereby balancing demand and capacity. It supports the tactical decisions concerning efficient utilisation of production, distribution and supply capacities (Stadtler and Kilger, 2008). The planning not only balances demand with available capacities but also assigns demands (production and distribution amounts) to sites and resources in order to avoid bottlenecks, wherefore it typically covers one full seasonal cycle, or at least 12 months in terms of weekly or monthly time buckets. Due to the complexity and details required in the model, normally only potential bottleneck and/or critical resources are modelled in detail.

To determine how actual customer demand (orders) should be fulfilled, the demand fulfilment module, including available-to-promise (ATP) and capable-to-promise (CTP) functionality, books orders against the capacity constrained master plan (Neumann et al., 2002). As such, order lead-times, suitable supply locations, available transportation resources, and available supplier material capacity can be established and communicated to the customer in a swift way (Steger-Jensen and Svensson, 2004). The customer order decoupling point (CODP) is of utmost importance to determine how the ATP process in demand fulfilment should be set up and how orders are booked against the master plan (Rudberg and Wikner, 2004; Wikner et al., 2007). Using ATP/CTP functionality in an APS to determine when an order can be delivered makes the order promising more accurate and reliable (Steger-Jensen and Svensson, 2004).
3.3 APSs in practice

Supply chain planning has in the recent years developed to be supported by optimization and simulation tools, especially concerning “higher” planning levels. Complex trade-off analysis can be calculated with the aid of optimization models and solution heuristics in relatively short computing time (De Kok and Graves, 2003; Chopra and Meindl, 2004). Cost minimization and profit maximization are the two most common ways to control the solution (Stadtler and Kilger, 2008). Many supply chain planning modules stem from in-house developed decision support systems (DSS) that aid planners at various levels in the decision hierarchy (De Kok and Graves, 2003). There are reports on some successful implementations of DSS in either special supply chain planning situations or optimization models regarding the entire chain. Gupta et al. (2002), for example, describe a DSS that helps Pfizer to plan their distribution network. The model is useful in both strategic and tactical planning situations. Brown et al. (2001) present a large-scale linear programming optimization model used at Kellogg Company to support production and distribution decision making on both strategic and tactical levels.

Jonsson et al. (2007) and Rudberg and Thulin (2009) both report on process industry companies using standard APS software at the mid-term tactical planning level, with the aim to enhance supply chain planning. Kjellsdotter and Jonsson (2010) study the potential benefits that could be reached by using APSs in the sales and operations planning process, also here for a process industry company. Zoryk-Schalla et al. (2004) describe a project where the case company, an aluminium manufacturer, implements three i2 modules for tactical and operational planning. Their major focus is however not on the effects of the implementation per se, but on the modelling of the planning processes and how the hierarchical planning structure can be captured in APSs. David et al. (2006) analyse the practical use of APS in the aluminium conversion industry, whereas Wiers (2002) presents a study on the integration of an APS and an ERP system in a steel processing plant. Our research reports on a longitudinal case study analysing both the tactical planning processes, and the effects from the APS implementation at the company. As such, we are able to determine the differences before and after implementing the APS system. Similar approaches have been used in the ERP domain (see e.g. Plant and Willcocks, 2007).
4. CASE STUDY: SSAB PLATE

4.1 The steel industry

From a general perspective, process industries include firms that deal with powders, liquids, or gases that become discrete during packaging. They include the pipeline industries such as refining, chemical processing, pulp and paper, food processing, textiles, and metals. Process manufacturing is defined by Cox and Blackstone (2002) as: Production which adds value by mixing, separating forming, and/or chemical reactions. It may be done in either batch or continuous mode. Process industries make up a large proportion of the manufacturing operations in the early stages of the overall production cycle of converting raw materials into finished products. Most process industries can be classified as either basic producers or converters, and sometimes a combination of the two (Finch and Cox, 1987). A basic producer is a manufacturer that produces materials from natural resources to be used by other manufacturers, whereas a converter changes these products into a variety of industrial and/or consumer products. As such, process manufacturers would be positioned in the lower right hand corner of the product-process matrix (Hayes and Wheelwright, 1979), typically producing commodities in high volume/limited variety. Whereas fabricators and assemblers (the two other categories in Finch’s and Cox’s classification) can be labour intensive, process industries rather have a high cost of capital invested in facilities. The steel industry that we are investigating is a combination of a basic producer and a converter, but apart from many other process industries, steel processing is in many parts based on discrete/batch processing (David et al., 2006; Wiers, 2002). Parts can be accumulated in queues, processed together in batches (e.g. for heating, quenching or ageing), or processed separately (e.g. rolling and machining). Therefore, the possible benefits from using APSs are most likely larger in steel industries, than what it is in more continuous processing (David et al., 2006). For our case company, which is a niche producer, the functional layout of the production process is even more noticeable.

4.2 Company background

SSAB Plate is part of the group Swedish Steel AB, which is a niche producer of high-strength steel with a yearly turnover of approximately SEK 48 billion during 2007 (1 SEK ≈ 0,11 EUR). In 2007 (the reference year for this study) SSAB Plate employed almost 2,500 persons and produced 586,000 tonnes of steel plate, which led to sales at SEK 9,941 million and a
profit of SEK 2,193 million. SSAB Plate is the largest Nordic manufacturer of heavy steel plate, with brands such as HARDOX and WELDOX, and runs a fully integrated steel mill from cooking plant to finished end products (see Figure 2). Approximately 90% of the production is exported worldwide. SSAB Plate has about 10,000 customers, with only two of them accounting for more than 10,000 tons, which in this context means that most of their customers are fairly small. The customers are served by about 200 sales managers and the mill is producing 24 hours a day, 7 days a week. Yet, the company is not able to satisfy the customers’ demand wherefore the company needs an extra focus on coordinating sales with production capacity.

![Figure 2: Schematic production layout at the manufacturing site at SSAB Plate.](image)

The tactical planning, which is in focus for this study, is organisationally located at the marketing department at SSAB Plate, managing the demand planning, master planning and demand fulfilment processes. The production department controls the operational planning levels, including detailed production and materials planning, scheduling and sequencing, and transportation planning. The two departments naturally interact, but since this study focuses on the tactical planning processes we are mainly concerned with the marketing department.
The marketing department is run by a marketing manager (MM) and the two main functions involved in the tactical planning are sales and master planning. The sales function, responsible for the demand planning process, is organised in different Business Areas, which in general are different geographical areas. Every business area has a Business Area Manager (BAM). The business areas are divided into smaller geographical Sales Areas which are divided into even smaller Sales Regions, each with their own managers; Area Sales Managers (ASM) and Regional Sales Managers (RSM). The organisation of the sales function has not changed due to implementing the APS modules, but the organisation of the master planning function has changed. The master planning function is responsible for the master planning and demand fulfilment processes and is after the APS implementation constituted by a small group of planners and system technicians. Before the implementation, the master planning responsibilities were divided between many functions and planners, making the process slow and cumbersome with poor visibility. In the following, we provide a background to the planning situation and planning problems triggering the search for better decision support in terms of APSs.

4.3 Planning situation and planning problems

There are two kinds of planning units at SSAB Plate; Stock Keeping Units (SKUs) that are made to stock and kept at warehouses around the world, and so-called Externalgrade Thickness Groups (ETGs) that are made to order and based on customers’ specifications. There are about 370 SKUs roughly accounting for 40% of the production capacity. Demand for SKUs is mainly triggered by re-order points in the approximately 80 stock points spread around the globe. The ETGs, which are a sort of product groups based on products with similar production characteristics, occupy the other 60% of the production capacity. There are some 160 ETGs and all are made to order with an order horizon of 12 weeks. The CODP is situated half-ways through the production process where the slabs are finalized (see Figure 2). The slabs are possible to store and a CODP buffer is placed at this location. After this point in the production process all orders are “unique” in terms of being linked to a specific SKU replenishment order or an ETG customer order.

4.3.1 Demand planning

In the beginning of the year 2000 SSAB Plate’s demand planning process was organised as follows. Every August, the RSMs made an estimate of their sales in tonnes for the forthcoming year and a half, because of an 18 months budget horizon. As time went by, the
sales managers had no possibility to change their forecast. The approximately 200 RSMs made their forecasts in various spreadsheets, with different layouts and non-standardized product names, just to mention a few of the experienced problems. One demand planner was responsible for merging the individual forecasts into one and another person was responsible for acting as a mediator between sales and production, to match the forecasted sales with the production capacity and allocate tonnes to the different RSMs. This meant that every RSM did get an upper limit, in tonnes, for their future sales, but to increase the possibilities of getting enough allocations the RSMs frequently overestimated their forecasts. It is easy to see several problems in this process considering there are about 200 RSM and a huge amount of products. Therefore, the demand planning process was fragmented with low forecast reliability.

4.3.2 Master planning

The master planning process was mainly a manual process, based on the consolidated yearly forecast, the current order stock (both SKUs and ETGs), and the stated available capacity. The balancing of demand and supply was done by matching lists from different legacy systems and spreadsheets, with the aid of personal experience and a multitude of phone calls. There were a few persons responsible for the balancing process, but the planning process per se involved a multitude of people from many departments and functions. The planning process as such was not clearly defined (e.g. in terms of workflows, activities, persons) and had no clear objective, leading to low accuracy and plans that neither satisfied demand nor were feasible in terms of production capacity.

The most severe problem was maybe that all planning (both sales and production) was based on tonnes of steel produced. Using tonnes as a unit for production is problematic because the required production capacity differs a lot depending on, for example, the specific plate and its thickness. To give an example; one plate of 6 mm HARDOX 400 uses roughly the same production capacity as one plate of 25 mm HARDOX 400, which implies that the 6 mm plate uses about 4 times as much capacity per tonne. This used to result in overbooking of capacity, since there were no other sales limits than the tonne allocations, which in turn caused delays in delivery of ETGs and unplanned stock out situations in terms of SKUs.
4.3.3 Demand fulfilment

To estimate delivery times, the company compared order requests (both ETGs and SKUs (stock orders)) with lists from the production planning systems used at the plant showing available capacity. The production planning system is a finite scheduler originally implemented as PMSIM, but later upgraded (through a series of vendor acquisitions) to Lawson M3 Advanced Production Planner (APP). The APP lists were showing total available capacity in the bottlenecks and orders were normally matched with the available capacity on a first-come-first-served basis. These APP lists were only updated every Monday, which meant that the available capacity could change and hence be overbooked at any time during the week without anyone noticing it. Furthermore, the problem of using tonnes as a unit of planning in production further enhanced these problems. The overbooking caused delivery delays and the rigid and ineffective planning process made the sellers overestimate their future sales just so that they wouldn’t run out of allocations. This in turn made the acceptance of the sales forecast low in production, i.e. there was a conflict between production and market and sales.

The planning situation at SSAB Plate was virtually impossible to handle and to get it working effectively. Therefore, the company decided that they needed to improve their overall planning, both in terms of decision support and in terms of reinventing their planning processes. The key goals at the time were to handle the increasing demand the company faced and to be able to give the customers accurate delivery promises, or alternatively turn orders down if there were not enough capacity. The later also highlighted the need to prioritize between customers and orders to be able to accept “the right” orders in times of demand surplus.

4.4 Planning solution

In 2001 SSAB Plate initiated a project focusing on streamlining the tactical planning and finding a decision support system that could help straighten out those complicated master planning processes. At the beginning of the project they evaluated 10 different APSs, of which three vendors were invited to demonstrate the systems on real data in the final round. The main focus was on the demand management, which was the function that later made them chose a product suite from i2 Technologies (from now on i2). This led to the implementation of three modules from i2’s suite; Demand Planner (DP), Supply Chain Planner (SCP) and Demand Fulfilment (DF), which were up and running by the end of 2002 (see Figure 3).
Figure 3: APS modules at SSAB Plate after the implementation of i2’s modules in 2002.

Figure 3 shows the implemented APS modules at SSAB Plate as of 2002. Besides the i2 modules and the Lawson M3 APP (that was already in place before the i2 project was initiated), a set of legacy systems also supported the tactical planning process and the APS. Figure 4 provides a schematic overview of the new tactical planning process. The following sections will describe the new planning processes and how they are supported by the APS modules (referring to Figure 4 throughout the description).
4.4.1 Demand planning

In DP about 1,000 of the largest customers are listed, with the smaller customers bundled together under each regional sales manager (RSM) as “others”. This grouping is done partly because they are small customers and it would take too much time and effort to place individual forecasts for each and every one of them, and partly because it is too difficult to estimate these customers’ demand, as it tends to be very irregular.

The current planning process starts with a manual forecast, as the RSMs use their experience to forecast the future demand and the future price per product and customer (‘A’ in Figure 4). The database includes three years of historical data, but this is seldom used to create statistical forecasts. SSAB wants 18 months forecast data in DP, and they require that the first six months are of good quality with high forecast accuracy. Every August, just before the budget period starts, the sellers are requested to update the entire 18 months of forecast. Except for this time it is up to the individual RSM to decide when to update their forecast, as long as the next six months is of good quality. In general the RSMs update their forecast once a month, leading to an 18 months rolling planning horizon. SSAB uses an order horizon of 12 weeks.
and in this near future the forecast is not to be changed. Beyond this 12 weeks time fence, the RSMs are allowed to change their forecast whenever they want. On the 15th of every month, the RSM forecast is transferred to what SSAB calls the final forecast, which is exported to SCP (‘B’ in Figure 4).

The RSM forecast is unconstrained, which means that they forecast what they could sell if they were allowed to sell as much as possible. This is important since the demand widely exceeds the supply and SSAB wants to use the demand instead of future sales in the planning process. Forecasted volume per month is entered into DP per consignee in tonnes per planning unit. Also the prices of the different combinations are forecasted, which is partly due to the profit optimizing objective that is explained in the sections below.

4.4.2 Master planning

The forecast information in DP is imported into SCP (‘B’ in Figure 4), where the first three months are disaggregated from monthly to weekly time buckets. SCP uses route sheets from an in-house developed mainframe computer system to calculate the needed capacity for each of the forecasts, and uploads available capacity and current workload from APP (‘C’ in Figure 4). To provide a description of the magnitude of the forecasting process, consider the fact that there are some 200 persons making forecasts in DP. Each of them forecasting for, typically, 20 customers specified so that every planning unit (SKUs and ETGs) is forecasted for every customer (both in terms of demand and selling price). This is specified per month, with the first three months disaggregated to weeks, which makes a lot of combinations and a lot of data to organise and process. In SCP, each individual forecast (RSM, consignee, planning unit, price and time bucket) is kept intact and matched with current available production capacity for the most critical 15-20 resources. The aim of the matching is to create an optimal product mix, based on profit maximization and a set of business rules that are decided upon by the company management.

The objective function in SCP is set to maximize profit, but SSAB controls the solution through a set of business rules that have priority over the profit maximization objective. In principle there are three sets of rules. The first set is of a geographical “fair share” type, ensuring a predefined minimum level of supply to different business areas. The second set of rules controls the ETGs and SKUs by prioritizing between customers and between ETG and SKU orders. The third set is basically the profit optimization objective, leading to that the orders with the highest contributing margin are prioritized so as to ensure that SSAB is using
the limited capacity in the most profitable way. The second set of rules is worth describing into somewhat more detail. These rules are based on a segmentation of the customers into 3 groups according to their importance, where group 1 contains the most important customers and group 3 the least important. There is also a fourth group which contains the stock orders from SSAB Plate’s own warehouses around the world. The general rules regarding which customers that should belong to the most important group is decided by the Marketing Manager, the other groups are determined by each BAM exclusively for each business area. Within the first three groups, a further division is made, which is based on an ABC classification of the forecasted revenue. The forecasted demand within each group is classified in terms of gross margin multiplied by tonnage, so that the forecast which generates most revenue within each group gets the highest priority. SSAB Plate typically uses three revenues classes within each group where the first class should account for approximately 20% of the total sales value within that group.

According to the explained business rules and the current production data from APP, SCP creates the constrained and optimized sales plan, which is a time consuming process that takes somewhere between six and ten hours. The constrained plan is then exported from SCP back to DP in terms of allocated tonnes per planning unit (ETGs and SKUs), consignee and time bucket (‘D’ in Figure 4), so that the salesmen can use DP to check their current allocations. As before there are problems with using tonnes as a unit, as it does not relate to the needed production capacity, but it is a well known unit that everyone understands.

4.4.3 Demand fulfilment

The constrained master plan is also exported from SCP to DF (‘E’ in Figure 4), but here it is done in hours per allocated resource, RSM, priority group and time bucket. At the time of the study there were approximately 120 defined resources in the system, but only 15 – 20 of these are critical in terms of capacity and used as allocated resources. When a salesman gets an order it is sent by e-mail or fax to the customer service department (‘F’ in Figure 4). Here the orders are entered into the order entry system (Jeeves) and further transferred to DF, which searches for available capacity for the salesman in the needed resources and time buckets. The allocated resources get a workload between 98 and 99 % because they are the resources limiting the production throughput, but they are also the ones important not to overbook since that unconditionally will cause delays.
DF is used to give accurate and fast order promising, with the use of the allocations planned in SCP. Information in DF is updated daily with the latest allocations from SCP and the current capacity and workload from APP. When DF gets an order request, it searches for available allocations to consume in the constrained resources according to the order routings that have been attached to the order. In the ATP/CTP search, the DF seeks for available capacity based on an appropriation system, which is based on the customer classifications as described in section 4.3.2. All customers are prioritized from one to four (SKUs making up the fourth class), where prio one are the most important customers. For a specific order request, DF first tries to find available capacity for the RSM in the customer’s prio group. If this does not exist, DF seeks for capacity in lower prio groups for the RSM. As a third step, and only for customers with prio three and above, DF seeks for available capacity, first in other RSMs prio four groups (in the same Sales Area) and then in other Sales Areas’ prio four groups. This method is used to level out the fluctuations in individual sales and the description above is the standard setting. Every BAM can decide exactly how and which appropriation rules that should be applied in their own Business Area. If DF finds available capacity a delivery promise is returned to Jeeves, which is thereafter sent to the salesman (‘G’ in Figure 4). If DF does not find available capacity within the requested delivery lead-time, a search for available capacity with delayed delivery is conducted. However, SSAB Plate does not normally accept orders beyond the 12 week time fence, wherefore order requests might be turned down. If orders are acknowledged they are loaded into the APP, hence consuming available capacity (‘H’ in Figure 4). The whole DF process is automatic from the time when orders are entered into the Order Entry system (Jeeves) and takes about three minutes for a “normal” order.

5. Case analysis and discussion

The general opinion at SSAB is that the new tactical planning process and the implementation of the three APS modules were necessary in order to get control of the diversified demand and master planning functions. Yet, even though the APS modules provide many positive effects, there are still a lot of areas where both the planning processes in itself, and the use of the software, can be improved. Some of them will be highlighted in the analysis below. Table I provides a short summary of the main issues that are analysed.
Table I: Case analysis highlighting the main issues before and after the APS implementation.

<table>
<thead>
<tr>
<th>Analysis issue</th>
<th>Before APS (prior to 2001)</th>
<th>After APS (as of 2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demand Planning</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision support</td>
<td>Various individual spreadsheets</td>
<td>i2 Demand Planner</td>
</tr>
<tr>
<td>No. persons involved</td>
<td>About 200 RSMs, one demand planner consolidating forecasts</td>
<td>About 200 RSMs, consolidation in DP for informational purposes only</td>
</tr>
<tr>
<td>Model design</td>
<td>Manual judgement of demand &amp; price</td>
<td>Manual judgement of demand &amp; price</td>
</tr>
<tr>
<td>Planning horizon/period</td>
<td>18 months</td>
<td>Rolling 18 months (6 m. “good quality”)</td>
</tr>
<tr>
<td>Planning frequency</td>
<td>Updated once a year</td>
<td>Updated once a month</td>
</tr>
<tr>
<td>Planning process</td>
<td>Fragmented, low visibility</td>
<td>Streamlined, high visibility</td>
</tr>
<tr>
<td>Main objective</td>
<td>Consolidating forecasts</td>
<td>Establishing reliable forecasts</td>
</tr>
<tr>
<td>Forecast accuracy</td>
<td>Overestimated forecast/ low reliability</td>
<td>Constrained forecast/ high reliability</td>
</tr>
<tr>
<td><strong>Master planning</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision support</td>
<td>Manual based on Excel-made budget</td>
<td>i2 Supply Chain Planner</td>
</tr>
<tr>
<td>No. persons involved</td>
<td>Many, but 3 with main responsibility</td>
<td>3 master planners</td>
</tr>
<tr>
<td>Model design</td>
<td>Manual balancing to find feasible plan</td>
<td>Plant loading based on a set of business rules, incl. profit maximization, to find an optimal plan</td>
</tr>
<tr>
<td>Planning horizon/period</td>
<td>18 months</td>
<td>Rolling 18 months, weekly buckets for first 3 months</td>
</tr>
<tr>
<td>Planning frequency</td>
<td>Monthly</td>
<td>Updated weekly, with a major replanning every month</td>
</tr>
<tr>
<td>Planning process</td>
<td>Fragmented, low visibility</td>
<td>Centralised, high visibility</td>
</tr>
<tr>
<td>Main objective</td>
<td>No clear objective</td>
<td>Max. throughput in bottlenecks and to prioritize profitable customers</td>
</tr>
<tr>
<td>Planning accuracy</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Run time (planning cycle)</td>
<td>N/A</td>
<td>6-10 hours</td>
</tr>
<tr>
<td>Planning output</td>
<td>Sales/production plan in tonnes</td>
<td>Constrained and optimized plans in tonnes (for DP) and in hours (for DF)</td>
</tr>
<tr>
<td><strong>Demand fulfilment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision support</td>
<td>Manual lists of available capacity (from APP)</td>
<td>i2 Demand Fulfilment</td>
</tr>
<tr>
<td>No. persons involved</td>
<td>One</td>
<td>Automatic process</td>
</tr>
<tr>
<td>Model design</td>
<td>Overloading possible due to allocations in tonnes</td>
<td>ATP/CTP functionality based on a set of priority rules (allocations in hours)</td>
</tr>
<tr>
<td>Planning horizon/period</td>
<td>N/A</td>
<td>12 weeks/real time</td>
</tr>
<tr>
<td>Planning frequency</td>
<td>Real time</td>
<td>Real time/ daily</td>
</tr>
<tr>
<td>Planning process</td>
<td>Fragmented, un-defined</td>
<td>Streamlined, automatic</td>
</tr>
<tr>
<td>Main objective</td>
<td>Accepting orders</td>
<td>Providing reliable order promises</td>
</tr>
<tr>
<td>Planning accuracy</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Response time</td>
<td>Long and unreliable</td>
<td>Acknowledged order in less than 3 min</td>
</tr>
</tbody>
</table>
5.1 Planning processes

5.1.1 Demand planning

The problem with the former demand planning process was the main reason triggering the APS implementation project. SSAB’s many RSMs did their work without any support from neither a standardised forecasting process nor any forecasting software. After implementing DP the process has been streamlined, but it was hard to make the autonomous RSMs accept the new forecasting procedures, which goes in line with what Wiers (2009) reports regarding shop floor autonomy and APS success. Hence, the SSAB management considered it impossible to also force them to use statistical forecasts as a basis for their input to the planning process. This is why all forecasts still are based on personal judgement alone, concerning both demand and selling price. The main difference with the new planning process is that it is standardised and that it is possible for the central management (i.e. the master planners) to overview the process, and that forecasts are updated regularly on an 18 months rolling horizon. It is also possible to give the RSMs a reliable feedback via the optimization in SCP. As such, the SCP provides a constrained forecast to all RSMs with the same granularity as was the case for the original forecast. This procedure guarantees that the sellers are controlled in terms of available sales volumes which is extremely important considering the demand surplus for SSAB’s products. Still some RSMs are using spreadsheets to create their forecasts, since they do not work in DP more than a couple of hours a month and by that don’t get comfortable in using DP. Although they are using these spreadsheets they need to transfer the information into DPs standardized form, which is a big improvement compared to before.

5.1.2 Master planning

An interesting feature of SSAB’s master planning process is that they do actually use profit maximization as the objective function in the SCP master planning. Otherwise most companies tend to use cost minimization (see e.g. Stadtler & Kilger, 2008; Wiers, 2002; Brown, 2001). However, due to the business rules used, there are only a few percent of the total demand that is actually affected by the profit maximization objective. Yet, SSAB has realized that in a world of capacity shortages it is of utmost importance to use the scarce capacity in the best possible way. The use of profit optimization is not uncontroversial at the company, and there are several opinions on how to calculate sales cost for different sales offices in different countries and there are managers claiming that profit optimization is a
short-term approach that makes the company more vulnerable in the long run. Concerning the planning process as such, the master planning has changed from being fragmented with no clear objective to become centralised with high visibility and a clear focus on maximizing throughput in bottlenecks and the company’s profitability. The plans resulting from SCP is also of higher accuracy and more easily accepted within the organisation, making the whole tactical planning process more reliable.

On the downside, it is worth mentioning that SSAB struggles with long run times in the SCP. This is partly due to that all forecasts for each single RSM and product group is kept as an individual “order” in the planning process. This makes the planning cumbersome and slow (6-10 hours per run), but the use of profit optimization require every order to be considered individually. SSAB also wants to communicate the constrained forecast after the SCP run to the forecasters, which also makes it impossible to consolidate the forecasts. As such, the main positive effects from the APS implementation lie not in reducing the planning staff and run times, but rather in the possibility to better plan the constrained resources and to provide detailed feedback to the forecasters/sellers.

5.1.3 Demand fulfilment

The demand fulfilment process is controlled through the constrained plan that the SCP provides. The DF output from SCP is based on allocations in hours (as compared to tonnes in the DP feedback). As such, SSAB is able to provide reliable delivery promises based on the constrained master plan, and also to search for alternative sourcing points and delivery dates, should a shortage occur. This was not the case prior to the APS implementation, when this process was based on manual lists from APP. Combining the DF with the constrained SCP also forces the company to keep within their capacity limits, and not overloading the resources as was done prior to implementing the APS. The DF is now an automatic process and consumes allocations and capacity in real time, even though a major update is done weekly, right after the SCP run. Instead of accepting orders to whatever cost, SSAB has adjusted the process so that they only accept orders that they actually can deliver, hence increasing the delivery reliability of accepted orders. Also, the new DF process is fast with an order acknowledgement (or reject) within three minutes.
5.2 Company performance and areas to Improve

The most important performance indicator for SSAB is delivery performance, and delivery performance has been kept on a stable level, although demand has almost doubled during the time from the implementation of the APS modules. The workload has thereby hit the roof and the initial improvement in delivery performance has diminished. Yet, SSAB has been able to assimilate this increase in demand and still been able to deliver on time, which is an indicator of a well functioning tactical planning processes. One should keep in mind that the production process in itself is far from stable, and there have been numerous severe break downs during the last few years that of course affect the tactical planning process and planning accuracy. The most constrained resources are loaded to 98-99 % which obviously makes it practically impossible to catch up after a breakdown in the manufacturing process. Yet, in spite of these problems SSAB has been able to keep deliveries on close-to-acceptable levels, which according to the company is thanks to the new centralised and visible planning processes and the new system support from the APS. In terms of cost, no big differences have been noted. The number of planners is approximately the same, but they are treating almost twice the number of orders without increasing the planning work force.

Company performance has been hard to measure during this study. This is partly due to the fact that SSAB has not kept track of performance indicators during the project, and partly due to that the changes in market and an unstable production process make it almost impossible to isolate the effects from the APS implementation. Rather than “hard” performance indicators, the benefits lie in “soft” issues, such as better visibility, higher planning accuracy, better customer service (more reliable and faster information to customers), and more standardised planning processes. Similar results have been found in other studies on APS implementations (see e.g. Kjellsdotter and Jonsson, 2010; Gruat La Forme et al., 2009; Rudberg and Thulin, 2009; Lin et al., 2007). Finally, and maybe the most important effect from the APS implementation – SSAB has established a standardised way to; (i) use their limited capacity, and (ii) to prioritize between customers and orders in accordance with the company’s long-term strategy. This would have been impossible without the APS support in terms of the SCP and DF modules. In many cases limited decision support makes it difficult to prioritize orders and customers, which is an important function for manufacturers with limited capacity and a high customer focus (Steger-Jensen and Svensson, 2004).

Even though the APS implementation overall is regarded to be successful at SSAB, there are many areas still to improve. SSAB strives for continuous improvement, and the demand
planning process has once again triggered an APS upgrade project that is currently on-going. An upgraded demand planning module has been implemented (i2 Demand Manager) and upgrades of the other modules are planned in the near future. In these upgrade projects, the following issues are the most important to consider in terms of improvement:

- The use of statistical forecasts as a starting point in the demand planning process.
- The reduction of run times for the master planning process
- The establishing of procedures for the profit maximization method, and to gain acceptance for this throughout the organization.

5.3 Summary and answer to research questions

The main purpose of this paper has been to describe and analyse the impact that the implementation of three APS modules has had on the case company’s tactical planning. Related to this purpose we raised three research questions in the introduction of this paper.

The first research questions concerned how the tactical planning processes have changed due to the APS implementation. First and foremost SSAB has managed to turn three manual and fragmented planning processes into more standardised processes with a higher degree of automation. Also, the former unreliable planning processes have now been turned into centralized, controlled and visible processes. The new processes also give central management better possibilities to overview the process and to control both the plans and the planners (e.g. in terms of forcing the seller to stick to the limits of the constrained forecast). All processes also have clearly defined objectives leading to that all planners are working towards the same goals. Even though the planning processes and the planning tasks have changed, the actual planning organisation has not. This could be a missed opportunity for the company, but the possibilities to also change the organisation in this case needs further research. Gruat La Forme, et al. (2009) also highlights that many companies implementing APSs have experienced a better overview of the supply chain. In this study this is also true, but more important is that the central planning function has got a better overview and visibility of the planners involved in the tactical planning process, and of the plans (forecasts) that they deliver.

The second research question highlighted the effects the APS had on company performance. First of all, it should be stated that the results from our research only reveals few effects on company performance that affects the bottom line. Measurable effects are that the forecast
accuracy is higher, a relative improvement in service-levels, a faster response time concerning order acknowledgement, and more reliable order promises. Similar effects have also been identified in earlier studies on APSs (improved forecast accuracy in Gruat La Forme, et al. (2009) and Stadtler and Kilger (2008); increased customer service levels in Gruat La Forme, et al. (2009), Stadtler and Kilger (2008) and Jonsson, et al. (2007); and improved on-time delivery in Gruat La Forme, et al. (2009), Stadtler and Kilger (2008), and Entrup (2005)).

Costs have not been reduced and we have not been able to detect any significant changes in revenues or profits due to the APS, which is contradictory to results in other studies (see e.g. Rudberg and Thulin (2009), Stadtler and Kilger (2008) and Jonsson, et al. (2007)). However, the performance of the tactical planning function has been improved in a number of ways; the plans are more frequently updated (also found in Stadtler and Kilger, 2008) leading to accurate planning data and better decision-making, the plans consider actual (rather than planned) lead-times and takes capacity constraints into account at all levels, and the company has also been able to find efficient means to prioritize between customers orders and to force the sellers to adhere to this prioritization.

The third, and final, research question was directed towards the advantages and disadvantages with the case company’s way of using the APS. Some of the advantages with the SSAB way of using the APS, is that the demand fulfillment process, in terms of planning, is a fully automated process with a fast response time (which is also supported by the findings in Stadtler and Kilger, 2008). SSAB has also used the system as the means to force planners to adhere to the standardised processes. Without the system support this would have been virtually impossible. The disadvantages lie mainly in the fact that SSAB has created a rule-based system, replicating parts of the old planning approach, overriding the true optimization. As such, the company does not use the full potential in the system to prioritize between orders and maximize profits. They have also kept their tactical planning on a detailed level with long planning horizon, leading to long run-times in the system. Finally, SSAB has missed out on the possibilities to integrate the APS modules in the tactical planning with the APS module at the operational planning. This means that SSAB are not able to optimize the operational schedules in accordance with the CTP calculation, which in turns leaves the company with far from optimal production schedules sometimes leading to inefficient use of the limited production capacity (e.g. in terms of unnecessary change-over between orders).
6. Concluding remarks

The main purpose of this research was to describe and analyse the implementation of APS modules for tactical planning in the process industry. This research points out the main lessons learnt from a longitudinal study at SSAB Plate. Internally the project is regarded to be successful and this research shows several positive effects, even though many of them are not measurable in terms of performance indicators. One of the measurable effects of the project is that the production almost doubled but the delivery performance stayed stable. Besides this a lot of “soft” effects has been noticed, such as; better control and higher visibility in the planning processes, a fast and reliable order promising process, and more standardised forecasting process leading to more accurate forecasts, to name but a few.

The reorganization of the planning function and the new planning processes are factors that also affect the performance, but the current situation could not have been realized without the APS. On the other hand the APS could not be effectively utilized without the organizational change. Lin et al. (2007) reveal that APSs should not be used to drive business process reengineering; rather process changes should precede APS implementations to overcome typical implementation pitfalls. In this case, the APS implementation project triggered the changes of the planning processes, but the APS did not drive the reorganisation. Lin et al. (2007) furthermore notice that effective management of processes in supply chains requires the use of APSs. On the downside of the project results are the fact that there are still some problems with the usage of the APS modules. This is partly due to that several of the company’s about 200 regional sales managers don’t know the system well enough to handle the demand planning module properly. Also there are a lot of functions and possibilities offered within the APS that are not in use. One reason for this is that the Marketing Manager and the sales function want to keep control of how planning is done within the company. Therefore the rule-based planning structure is dominating, even though master planners want to give the APS more “freedom” in creating optimal plans with a higher degree of profit maximization.

The results from this case study may not be applicable to other situations. However, the process descriptions, lessons learnt and issues encountered in case studies like this may be helpful to practitioners on their way to implement APSs, and for academics studying APS implementations and their effects (Wiers, 2002). Companies seeking new ways to improve their planning can use this research to investigate the use of an advanced planning system at
SSAB and make comparisons with their own situation. As such, they will get better insight into what is to be expected from an implementation project, both in benefits, but also in what efforts it takes to avoid pitfalls and create a stable solution. Managers will hence be able to use this paper, both as guidelines and as a comparison during and after their own project.

SSAB is in the middle of a number of upgrade projects and future research on the subject will focus on how planning is improved further in this context. Also, there is a need to analyse “hard” figures concerning planning and delivery performance as a result from implementing APSs, with the changing of planning processes and organisation as a major influencing factor. From a general perspective, future studies could also focus more on the implementation process per se, and how it affects the possibilities to realise the expected effects from using APSs. For example, Plant and Willcocks (2007) investigates how critical success factors in ERP implementation influence the outcome of the implementation. Similar studies are needed for APSs implementation. User training may be a factor contributing to the challenges in implementing an APS, and so are top management support and leadership. All of these factors are worth investigating in further research on APSs.

References


Companies operating in environments where demand supersedes production capacity often use some kind of customer segmentation to choose between orders. This calls for the need of methods for creating the best possible allocation of the capacity to different segments or customers, in order to maximize the company’s profit. In their need to fulfil this request, several companies have chosen to utilise the decision support offered by several advanced planning systems vendors, which aims at creating a more profitable utilisation of the resources with regard to the customer segments. The purpose of this study is to analyse the capable-to-promise functionality in a demand fulfilment process concerning segmented customers. A literature study is conducted and a process industry company, with finish to order production, is described and analysed. The company has experienced good results from using an APS’s demand fulfilment functionality. The main findings are the verifications of some theoretically expected benefits, such as customer service level and product mix composition.

Keywords: advanced planning systems, available to promise, demand fulfilment, customer segmentation, process industry, case study
1 Introduction

In times of increasing competitiveness the importance of operations planning becomes apparent in a wide range of industries. This has, in combination with the recent development of decision support systems, put focus on the use of Advanced Planning Systems (APSs), since these systems offer a possibility to increase companies’ effectiveness and overall competitiveness by means of planning improvements (Stadtler and Kilger 2008). Late 2008, Gartner, Inc. concluded that the two top business priorities for enterprise executives worldwide were to improve business processes and to reduce enterprise costs. The corresponding top technology priorities were Business Intelligence and Enterprise Applications, where both ERP and APSs are included. Gartner, Inc. also predict that the IT spending in the manufacturing sector will increase again after the big drop during 2009 (Gartner Inc. 2009). These are signals that the area of APSs, and other enterprise applications, is getting more and more important in industry, which in turn will make research in this area a question of current interest for many years to come.

An APS can be seen as a supplement to an enterprise resource planning (ERP) system, as an APS extract and use data from the ERP system. APSs support planning over a wide range of processes and, as ERP systems, they are often modular, which means that a user can chose to implement only one module concerning one process, or several modules covering a range of processes (Gupta 2000). This is used as a way to classify standard APSs, namely by categorising the different software modules depending on which supply chain process they support, as seen in figure 1 (Stadtler and Kilger 2008). This study focuses on demand fulfilment, but as such the module that we analyse is dependent on the demand planning, master planning, and production planning/scheduling modules in the order fulfilment process.
When studying DF in different APSs one will find several solutions to assist in assigning priorities to orders and/or customers. The basic idea of this approach is to use segmentation of customers as a means to increase the total revenue, for example by only accepting the most profitable orders (Meyr 2009). In the manufacturing industry this is extremely relevant, especially in cases where capacity constraints force companies to continuously choose between different customers and reject orders due to capacity shortages. This issue can be handled by allocating production capacity in advance to different customer segments and then only accept orders from customers belonging to segments with available allocations. The process of conducting this is denominated allocation planning.

The purpose of this study is to analyse the use of an APS in a demand fulfilment process, with focus on capable-to-promise functionality for segmented customers. The analysis aims at first describing the theoretical effects that can be expected, and then contrasting these with a case study.
From a methodological perspective, this research is based on a literature review and a case study; the case being conceptual and descriptive in nature (Yin 2003). The literature review is founded in the fields of supply chain management, operations management, and advanced planning systems. The case study is based on data gathered through semi-structured interviews and on-site visits at the plant, as well as data from the company’s internal documentation. The authors also had access to primary data in terms of company reports describing processes, performance data, etc. Typically, interviews were carried out with project managers, process owners and planners. The research aims at evaluating the case based on theoretical aspects on demand fulfilment, capable-to-promise (CTP) and revenue management, so as to exemplify and enhance the understanding of the use of sophisticated APS modules in practice. The case describes and analyses the demand fulfilment process in a capacity constrained setting with both stock orders (make-to-stock, MTS) and customer orders (make-to-order, MTO).

The company operates on a global market with regional sales managers in more than 45 countries. For many years, capacity constrained planning has been of utmost importance for them, since their demand normally widely exceed their production capacity. The implementation of a commercial of the shelf APS suite a few years ago gave them the possibility to exploit their customer segmentation in a more structured way. Now the company have used customer segmentation in their master planning and demand fulfilment processes for a couple of years, treating both MTS and MTO products, and their opinion is that they have experienced satisfactory results.

Before going into more details about the case, we start off with a brief account on the order fulfilment process, including customer segmentation and CTP functionality, in APSs. Thereafter follows the case study and the case analysis. Finally
we conclude the paper and provide the most important lessons learned from the case and ideas for further research on the subject.

2 Literature Review

2.1 Order fulfilment process
An important issue for many companies with order driven production processes is to be able to give accurate order promises. The improvement of order promise accuracy has been shown to be one of the main aims of companies when deciding to conduct APS implementations (Gruat La Forme et al. 2009). To achieve this, the order promising process must be based upon the actual planning constraints facing the company; constraints based on either material or capacity (or on both). Material constraints are those related to the limited availability of material (raw material, modules, finished goods, etc.), whereas capacity constraints are associated with limited productive resources. Traditionally, quoting delivery promises has been based on available inventory, and if no such exists, on the planned production lead-time (Kilger and Meyr 2008). This is not sufficient if the company wants to improve the quality of their order promises, which also is described by Bixby et al. (2006). Modern order fulfilment solutions based on the planning capabilities of APSs offer more sophisticated order promising procedures with the aim to; improve the on-time-delivery by generating reliable quotes, reduce the number of missed business opportunities by searching more effectively for a feasible quote and increase revenue and profitability by offering less discounts due to high inventory levels and hence increasing the average sales price (Kilger and Meyr 2008). In the following APSs and Customer Segmentation is briefly described in general, where after the available-to-promise (ATP) and CTP functionality in APS is described in somewhat more detail.
2.2 Advanced Planning Systems
Unlike traditional planning within ERP systems, an APS tries to find feasible, near optimal plans across the supply chain as a whole, while potential bottlenecks are considered explicitly (Stadtler and Kilger 2008). In terms of software, APSs means a broad group of software applications developed by various software vendors, such as i2 technologies, JDA, Oracle, SAP and Lawson. APSs, try to automate and computerise the planning through simulation and optimisation (Chandra and Grabis 2007) and aim at taking into account the finite nature of resource capacity and other constraints in order to provide reliable planning (Neumann et al. 2002). They do not, as the MRP logic within traditional ERP systems, assume that capacities are infinite, that all customers, products and materials are of equal importance, and that certain parameters (such as lead times) are deterministic (David et al. 2006).

2.3 Customer Segmentation
In a capacity constrained setting, not all customer demand can be satisfied and fulfilled, which makes the demand planning and master planning even more important. The important task is not just to plan the operations effectively but also to allocate certain capacities to the most important customers. Quantity-based revenue management methods can be used to segment customers into several groups depending on differences in buying behaviour, strategic importance, average profits, and the like (Kilger and Meyr 2008). For a comprehensive review on early revenue management, mostly focusing on the airline industry, we suggest McGill and Van Ryzin (1999).

APSs support the use of customer segments in order to improve the overall business performance. The allocation of ATP/CTP to customer segments can be exploited to increase the revenue and profitability of the business. This procedure is denominated allocation planning (Kilger and Meyr 2008), and it starts with the transformation of the adjusted forecasts (from the demand planning module) into
ATP/CTP quantities by the master planning module. Thereafter the quantities are allocated to the customer hierarchy according to pre-defined business rules, and these allocated quantities are in turn used by the demand fulfilment module as order requests are processed. With use of this allocation planning, the system prevents less important customers to use allocations reserved for the more important ones.

2.4 Capable-to-promise (CTP) and Available-to-promise (ATP) functionality
Consider a company that assembles pre-designed and pre-produced modules to customer orders, whereby an order promising process has to focus on two major issues. First, the buffer of available modules, which normally coincides with the point in the goods flow where a customer order is fed into the production process (i.e. the customer order decoupling point, CODP). The second issue is the available capacity (capability) in the final assembly production, which Spengler et al. (2007) state should be in focus as the usage of the resource oriented factors directly affects the company’s total profit if they suffer from scarce capacity. The former is usually labelled available-to-promise (ATP) functionality in production planning and control terminology, and is defined as the portion of the on-hand inventory and planned production (master production schedule) that is not already allocated to specific demands and are still available to satisfy new demands or demand configuration changes (Higgins et al. 1996). ATP allows delivery promises to be made, and customer orders and deliveries to be scheduled accurately. The latter of the issues, concerning available capacity, is labelled capable-to-promise (CTP) functionality, which is an extension of the traditional ATP with the additional option of taking the available and finite capacity into account so as to calculate when a company is capable of assembling modules into a final product, or producing the missing parts in an order (Rudberg and Wikner 2004).
2.5 Customer segmentation and CTP in Practice
The overall goal of this paper is to study customer segmentation and profitability considerations in the order promising process. Kirche and Srivastava (2003) argue that revenue based management is important in most industries facing limited capacity. Acknowledging that a company’s processes have finite capacity means that a firm would be willing to reject some orders if they cannot be delivered at the due-date without hurting the overall profitability of the firm (ibid.). By rejecting some orders with low profitability, a company opens up for the opportunity of accepting orders of higher profitability in the future.

Bixby et al. (2006) stated that a CTP application at Swift & Company improved the on time delivery most during periods with high demand, which lead to the conclusion that the system is most helpful when the demand and the business complexity increase. Another result found by Bixby et al. (ibid.) was that the CTP application increased the average sales price, as the inventory levels decreased and they because of that had less price discounts. Holland Colours chief finance officer states that the company´s use of an APS with CTP functionality has increased their customer service levels and has made them able to utilize their production resources better (Tinham 2006). At SKF Linear Motion the main benefit derived from the use of a demand fulfilment module is that they never have to say no to a customer, as they now are able to see all the alternatives. They have also seen benefits such as reduced inventory levels and more reliable lead times (Schultz 2002). Kilger (2008) considers a computer assembly company, where the use of an APS including a demand fulfilment module has improved the customer service level and the delivery reliability and hence resulted in additional revenue.

Quante et al. (2009) states that an issue in practical use of demand fulfilment modules is how to get a good balance between the solution quality and the response
time for the order promise. The question of response time is a major factor also in the development of a scheduling and CTP application at Swift & Company, as described by Bixby et al. (2006). A major replanning or batch processing of order requests would increase the degrees of freedom and hence improve the solution, but will also inevitably result in longer response times.

This study’s purpose is to consider the order promising process and explicitly the use of a demand fulfilment module with CTP functionality. The accounts on successful APS implementations are increasing and some of the, so far, quantifiable benefits that are related to the use of the demand fulfilment module are listed in Table 1.

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<th>Improved on-time-delivery</th>
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<td>Reduced total cost</td>
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<td>Increased average sales price</td>
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Table 1 Results stemming from DF in published literature

The reduction in inventory levels, as described by many authors, is a common result, since companies are used to keeping track of their inventory levels. This result stem from several things, but one of them is that the DF module improves the order promising process so that a larger portion of the production is tied to orders in advance, which means that those products never have to be stored.
The on-time-delivery and the increase of customer service level are two results that, when studying these DF accounts, stem from the fact that the order promising now takes into account the finite nature of the production resources and hence the delivery promises are based on the company’s real situation.

The increase in average sales price is a result with two causes; first the fact that the company is more likely to turn down less profitable orders as more profitable orders are expected, and second that some products with limited shelf life will not have to be offered at large discounts to the same extent as before.

A production that is more synchronized with demand and a more optimized product mix are benefits that both stem from the fact that the system helps to plan incoming orders in accordance with what is possible to deliver, so that the production resources are better utilized.

The improved utilization of resources is also a factor when looking at the improvement in the reliability of delivery lead times. This is partly a result of the company not overloading their resources, as overloading inevitably has long and uncertain waiting times as a direct effect.

By implementing a DF module a company can hence have expectations that some of the improvements in accordance with Table 1 will become apparent. In the following we will describe a case company using customer segmentation, based on gross profit, in combination with an APS suite including allocations and CTP calculations in a capacity constrained environment.

3 Case Study: SSAB Plate

3.1 Company Background

SSAB Plate is a niche producer of high-strength steel and the largest Nordic manufacturer of heavy steel plates. In 2008 they employed 2,500 persons, had annual
sales of SEK 13.2 billion and a profit of SEK 3.1 billion. The sales function at SSAB Plate is organized in business areas (in general different geographical areas). Every business area has a business area manager, and is divided into smaller geographical Sales Areas and even smaller Sales Regions, each with their own managers; Area Sales Managers and Regional Sales Managers (RSMs). The customers are served by about 200 RSMs which all have a common goal, to deliver the steel plate that the customers want to buy.

SSAB Plate runs a fully integrated mill, from coking plant to finished plates (see Figure 2), in Oxelösund in Sweden. Even though the company can be characterised as a process industry with a divergent material profile, the mill is operated as a job shop with batch production and variable routings, mainly due to the fact that the company is a niche player with more than 10,000 customers, of which only two of them account for more than 10,000 tons annually. In the context of the steel industry, this means that the vast majority of SSAB Plate’s customers are small.

The product as such is fairly standardised, but with a broad set of final product types and many small orders, which makes the planning of the mill a challenge. The mill has some 120 defined resources, of which some 18-20 are regarded potential bottlenecks that vary depending on the product mix. Approximately 40% of the production volume is stock replenishment orders for some of the 80 stock points spread around the world, whereas the remaining 60% consists of customer orders. The production can be characterised as finish-to-order (FTO) production, as the CODP is approximately halfway through the mill. The CODP buffer consists of slabs, which are finalized according to stock or customer order specifications, hence the characterization as FTO production.
3.2 Planning situation
The demand facing SSAB Plate has for many years widely exceeded their production capacity, which has made the company search for ways to increase their output. This study considers this capacity constrained environment, which is SSAB Plate’s normal operational state, meaning that the mill in Oxelösund is producing 24 hours a day, 7 days a week and is still not able to satisfy the customers’ demand. Thus, the analysis will be based on the assumption that the demand cannot be satisfied and that some kind of segmentation is needed. This is also identified as the situation where the use of CTP functionality is most beneficial (Bixby et al. 2006).

In 2001 SSAB Plate implemented an APS suite from i2 technologies, with the main purpose to increase output by performing more effective planning (Cederborg and Rudberg 2008). The i2 suite implemented included the following modules (see Figure 3); Demand Planner, which was later upgraded to Demand Manager (i2 DM), Supply Chain Planner (i2 SCP) and Demand Fulfilment (i2 DF). SSAB Plate already had an APS module for production planning and scheduling called PMSIM (formally Lawson’s M3 Advanced Production Planning module). SSAB Plate also has a set of in-house

Figure 2 SSAB Plate’s Supply Chain
developed systems to support the planning process. The order fulfilment process leading to an order promise can be said to be constituted by three parts; 1) demand planning, 2) allocation planning, and 3) demand fulfilment (see Figure 3), all of which will be described in the following. To be noted is that the planning units in the order fulfilment process are External Thickness Grade groups (ETG), which basically are bundles of products with similar characteristics.

![Figure 3: Overview of the order fulfilment process (including demand- and master planning). The cylinders represent IT systems, the parallelograms represent humans and the arrows represent data flows.](image)

### 3.3 Demand Planning

The demand planning in i2 DM is done by the RSMs on a rolling 18 months horizon, of which the forecast for the coming six months is supposed to be of good quality with high accuracy. This means that, in general, the RSMs update their forecast once every month to achieve the sufficient forecast quality. This is done with respect to upper boundaries defined by the budget, which prevent shortage gaming by the RSMs. Apart
from volume, the price is also forecasted for each ETG and each consignee (the person to whom the shipment is to be delivered).

3.4 Allocation planning
The forecast from i2 DM is the foundation for the master planning process and it is transferred to i2 SCP once every month. The process starts with the forecast netting, as open orders are subtracted from the forecast. The netted forecast, which is kept on a detailed customer, quantity and delivery date level, is then prioritized according to a set of business rules. In this process, SSAB Plate uses four broad groups to prioritize their customers, which also decide the priority of the orders:

1) customer orders from the most important customer group
2) customer orders from the second most important customer group
3) customer orders from the least important customer group
4) stock orders from SSAB Plate’s warehouses

The rules for the segmentation as such are decided at different levels in the company. The decision concerning which customers that should belong to the highest prioritized group is made by the marketing manager, but the other two groups are decided by the manager of each business area. Within the first three groups (Priority 1-3), all orders are further divided based on an ABC classification of the profitability in terms of gross margin multiplied by tonnage. This gives the most revenue yielding forecasted demand highest priority within each of the three priority groups.

On top of everything SSAB takes into account a “fair share” logic between the business areas, which is supposed to guarantee a certain level of supply to the different business areas. If this logic was not used, some countries, with relatively low sales prices, would not get any supply at all in the end. Hence, the BAM guarantees put a strategic focus on the planning as lower bounds for the optimization in i2 SCP.

i2 SCP optimizes the plan for the prioritized netted forecast, considering the available resource capacity, the gross margins associated to each demand and other
restrictions based on the set of business rules (see below). i2 SCP is run daily and creates an optimal product mix and allocations. At that time capacity and workload data are uploaded from the detailed planning and scheduling tool Lawson M3 APP. The results from i2 SCP are allocated tons per ETG, consignee and time bucket, but also allocated hours per resource, RSM, priority group and time bucket. The current status regarding allocations in tons is exported to i2 DM once every week, so that every RSM will have access to updated information on a weekly basis. The allocations in hours is exported to i2 DF and used in the demand fulfilment process.

As described above, the i2 SCP is run daily to establish a constrained plan based on profit maximization in order to create allocations for each group, which is later used in the demand fulfilment process. When running the planning engine in i2 SCP it is guided by the following set of business rules (in order of priority):

1) Respect the “fair share” logic
2) For customer orders (priority 1, 2 and 3), including ABC sub-classes:
   a. Maximize the planned quantity
   b. Minimize the quantity planned late
3) Maximize the planned quantity for stock orders (rank 4)

To summarize the allocation planning, SSAB Plate can be said to use a margin based revenue optimization to create allocations in the master planning process. The idea is to consume capacity and by that create allocations for the most revenue yielding customer demand first. This applies to demands of the same rank only; higher ranked demand will always have priority over lower ranked demand. When the allocation planning is done the results, in terms of allocations in hours per resource, customer group, seller and time bucket, is exported to i2 DF and used for order promising, as described below.

3.5 Demand Fulfilment
The Demand Fulfilment process is used to give accurate and fast order promising based on the allocations determined in the master planning process, and based on a set of
priority rules (related to the ranking of customer groups). The demand fulfilment engine supports search for supply (ATP) and capacity (CTP) in three dimensions; time, seller and product. The information in i2 DF is refreshed daily with the latest allocations from i2 SCP, the latest orders, and the current capacity and workload from the production planning module. i2 DF allocates the capacity requirements according to a RSM hierarchy, based on the allocations from the master planning in i2 SCP. During the day the i2 DF engine communicates on-line with the order entry system (Jeeves OES). New orders, inquiries and reservations (or changes in the existing ones) are sent to i2 DF, which replies with a promised shipment date. This calculation considers the required routing and search for available resource allocations.

The demand fulfilment process starts when orders are entered in Jeeves OES, which interacts with the mainframe computer to get the routing and manufacturing lead-times for each specific order. The combined result is sent to i2 DF together with information about the seller (RSM), the customer’s priority group, and the requested delivery time. The current workload and available capacity is uploaded to i2 DF from the production planning module every night.

When checking for a possible delivery date, i2 DF first takes into account if material is available (in the CODP buffer). If so, the routing sheet is specified without the production of the material. If not, the routing instead includes the standard lead time for the production of slabs in the total manufacturing lead time. During order promising the routing of a product is created and available capacity is searched for at all the constrained resources. The routings contain the sequence of operation steps that are needed to manufacture the product. These steps are specified with operation time and required capacity for every step and are used when an order is consuming time from the allocated resources. During the CTP search the system checks for available allocations
at all constrained resources in the following order, starting with allocations from the RSM who requests the order:

1) At first in the customer’s priority group; starting with the requested delivery date and, if no allocations are found, continuing with earlier time periods (leading to more tied-up capital).
2) If no allocations are found in the first step, the search continues in lower ranked priority groups according to a so-called appropriation system (further described below). Also here, the search starts with the requested delivery date, and continues with earlier time periods if necessary.
3) Finally, the CTP engine searches for allocations in later time periods (leading to a delay compared to the requested delivery date).

The appropriation system is used when a RSM is lacking allocations for a certain priority group. The system includes rules that regulate how RSMs can use allocations from other priority groups (normally within lower ranks) and also from other RSMs’ allocations (also here normally for a lower prioritized allocations). These rules are specific for each business area. Allocations are held at the RSM and priority group level, wherefore no customers and consignees are modelled in i2 DF. One order consumes allocations on many resources, leading to a reduction of available allocations if the order is booked. If allocations in high priority groups are not reserved by orders they are released for anyone to use, no matter priority. This is done four or five weeks in advance, depending on the resource.

When allocations are found in i2 DF, a promised delivery day is returned to Jeeves OES. The search for allocations in i2 DF is in average done in three minutes, but if an order has many order lines the system may need up to ten minutes to finish the operation and return a promised delivery date.

4 Case Analysis
At SSAB Plate the use of advanced planning is not a new phenomenon and they have an operating environment were optimization models have been used in production planning
for many years. Yet, trying to optimize the use of capacity (allocations) in the order fulfillment process is rather new, but overall it is a process that SSAB is pleased with.

The benefits derived from the demand fulfillment process, as found in other documented cases (Table 1), have been studied at SSAB. They have not been able to verify any changes in inventory levels, although this is one of the most commonly seen results in literature (Tang et al. 2001; Rudberg and Thulin 2009). Neither have they seen any changes in the average sales prices outside of what is normal. Since the company can be classified as an ATO company, the synchronization of production and demand has always been quite high, but one thing that has changed is that the product mix is more in line with what the production resources are able to produce. Orders that cannot be produced within the time frame are now rejected or postponed, which leads to a better utilization of resources with regard to the product mix.

When comparing with the situation before the APS implementation, the on time delivery has been kept on a stable level at the same time as the sales have almost doubled, which most certainly is to be classified as an improvement. One cannot exaggerate the importance of accurate delivery promises (Bixby et al. 2006). By using the described systems and modules, SSAB Plate has a process that is able to give a delivery promise to their customers within a couple of minutes, which is fast enough in their setting. The delivery promises are based on calculations which use of current capacity and workload in production (updated every night). This leads to more accurate delivery promises, which is one of the benefits that have been verified at SSAB Plate, as well as in other cases as stated earlier (Lütke Entrup 2005; Kilger and Meyr 2008). The accuracy of delivery promises and the improvement in the on-time-delivery have also led to an increase in the customer service level at SSAB.
The business rules have the effect that all priority groups are guaranteed a certain amount of supply. This will assure that every group will get some allocations, in parity with the forecast for that group. To prevent shortage gaming, there is a upper limit for the forecast from the RSMs. But in this setting we must also consider the appropriation system, which state that higher priority orders can use allocations from lower priority groups if no allocations are available in their own priority group. This implies that the low prioritized customers normally will be affected and not getting delivery promises as they wish. The customers that are seen as important should more often get the delivery promises they wish, thanks to the described policies. The question of segmentation is of course important within the company. Customers who are put in lower priority groups may end up without supply more often which means that they will have to look to other suppliers for their goods. This adds a risk that SSAB is well aware of, that a new, less important, customer might be an important customer in a few years’ time. Turning down this customer might imply losing a long term contract that would be very profitable. SSAB has chosen to put their priorities on customers with whom they have a good relation and from their point of view the segmentation is a way to keep the most important strategic and profitable customers, those that the company cannot afford to lose.

One of the biggest challenges for the demand fulfilment process in a MTO (or as in this case, a FTO) setting is to implement the model in practice and to get a good balance between solution quality and short response times (Quante et al. 2009). At SSAB the response time for the DF process is less than 10 minutes (in average about 3 minutes). This point to the fact that the company have put a lot of focus on short response times, which may result in negative effects concerning the quality and reliability. A simple way to increase the degrees of freedom in the optimization, and
therefore most likely improves the solution, is to use batch processing of the delivery promise requests. However, this will call for a change in the overall processes, since delivery promises then have to be postponed, but still it is a possibility worth studying in more detail. At Swift & Company, as described by Bixby et al. (2006), their equivalence to SSAB’s RSMs uses the DF functionality in real time, which gives them the possibility to check for and reserve allocations when on the phone with customers. This made the response time extremely important in the Swift & Company project and they managed to get their response time reduced to seconds. At SSAB this is not as important, as their RSMs do not use the functionality in real time, which gives them an option; either to have short response times at the expense of the solution quality or to use batch processing and get a more efficient plan at the expense of response times.

5 Concluding Remarks
The purpose of this paper is to analyse the use of APS in a demand fulfilment process, with focus on capable-to-promise functionality for segmented customers. We have derived a number of theoretical effects that can be expected when using a demand fulfilment module and we have also described a case company where the use of an APS suite has proven itself to contribute to several positive changes.

Trying to assess the potential benefits of a future implementation of an APS has shown itself to be a difficult task. Any company in the process of deciding whether to initiate an APS project or not will face these questions and there will be debate on the possible improvements. Looking at the literature and the SSAB case described here, we conclude that there are many positive results that can stem from the use of an APS, but it is not for granted that these benefits will appear at any company. In this paper we have shown the effects that have been realized by a company using customer segmentation and advanced capable-to-promise functionality in their order fulfilment
process. The description gives an overview of the solution the case company has chosen, and it provides the reader with a better understanding of the underlying functionalities in an APS.

From a managerial point of view the achieved benefits that have sprung from the use of the APS are; improved on time delivery, increased customer service level, better optimization of the product mix and a more reliable delivery lead time. Of course there is a possibility that some of the benefits partly stem from other changes made during the process, but at SSAB they are convinced that the improvements would not be possible without the use of an APS.

The fact that this research is based on a single case study implies that the generalization of the results is to be taken under careful consideration. It also calls for further research on the subject, both in terms of quantifying the effects of the implemented systems and in terms of comparing to other cases where similar approaches are used in the demand fulfilment process. Although the accounts on actual implementations of APSs are increasing, the unique situations in different industries make it an interesting and needed area to study. With this study, concerning an APS in the process industry setting we have filled a part of that gap.

When conducting this study, we have concluded that the business rules are essential in sticking to the company’s strategic choices. But the prioritizing of customers raises another question, how would the optimization turn out without the limitations and boundaries that are not a result of real resource limitations? One thing that most likely would happen is that some countries would not get any supply at all, since the market prices in those areas are much lower than in other areas. But what would the impact be on SSAB’s overall profit? The strategic decision that has been made is that some supply should be guaranteed for all areas, but what is the alternative
cost of such a decision? Also, what should the effects on a profit maximized plan be in the production processes, which are known to be both complicated and volatile? SSAB has never tried to create a plan based on the profit maximization alone, the major reason being that they cannot accept just parts of a customer’s demand; they must offer the whole package. Hence, SSAB cannot focus on the most profitable products alone, since their customers often need both profitable and less profitable products. Well used, the business rules create frames that force the system to allocate capacity to these less profitable but, from a customer perspective, crucial products. Still, it is a trade-off between strategic and financial decisions, which has to be made. Even in this setting the comparison with a fully profit optimized plan would provide information for managers, when making the decisions. Another reason why profit maximization is not used in full has its explanation in that SSAB historically has focused on produced tons rather than hours needed in production. Any organizational change is a time consuming and effort taking task. Since this focus on tons can somewhat contradict a possible focus on profit it should be of interest to compare a profit maximized plan to a plan created with the business rules as of today.

A proposal for future research is to do simulation runs with optimization models that are executed in scenarios where the different mathematical constraints can be added or removed. This would provide information on the gap between the different solutions and it would be interesting knowledge both for practitioners and for the academic community.

Another interesting question is; how do you find the customers with potential to grow, in other words the ones that should be given high priority? In this study the initial customer segmentation is not examined, as it is based on arbitrary assumptions and objectives, which are not quantifiable. We cannot describe why a customer has a certain
priority, but nevertheless we show that the prioritized customers are given better conditions, no matter how the priorities are determined. In the future, the segmentation as such should be studied in detail.

6 References


Cederborg, O. & Rudberg, M., Year. Advanced planning systems: Master planning in the process industry. EurOMA 2008 Conference, Groningen, the Netherlands.


Assessing factors affecting results of APS implementations

Ola Cederborg
Department of Management and Engineering
Linköping University
SE-581 83 Linköping, Sweden
ola.cederborg@liu.se

Abstract

Purpose

The purpose of this paper is to study if ERP success factors are applicable in APS implementations.

Methodology

A multiple case study including four companies that have implemented an APS concerning their tactical planning process is conducted. Critical Success Factors derived from the ERP literature and described effects from APS implementations are studied at the companies. The cases are compared concerning their fulfilment of the critical success factors with respect to the effects they have experienced.

Findings

Findings show that several critical success factors concerning ERP most likely are applicable in APS implementations. Also, the findings verify some of the previous described effects from APS implementations.

Practical implications

The findings show some factors to pay attention to when going through APS implementation projects. They also show some of the effects that can be expected if succeeding with the APS implementation. Both these implications are of use to managers that consider implementing an APS.

Originality/value

Studies considering success factors in APS implementations are lacking in the published literature. Testing ERP success factors application on APS implementations has not been done before. The findings of this paper fill some of that gap.

Keywords: advanced planning systems, critical success factors, multiple case study
1 Background

Manufacturing companies of today are facing everyday challenges in making their production as efficient as possible. The evolution of planning has led to many vendors offering complete suites of planning systems which use advanced mathematical algorithms and optimization methods to solve planning problems with multiple sites, multiple products, dynamic bills of materials and multiple resources with capacity constraints. To conduct this kind of planning without the use of any supporting system would be virtually impossible, especially within a reasonable time frame, which is why many companies chose to implement an Advanced Planning System (APS). By doing this they want to provide their planners with tools to improve the planning and hence make the company as a whole more efficient.

In literature there are accounts on both successful and unsuccessful APS implementations, which raise the question: How do you make an APS implementation a successful one? The question of successful implementations has been examined by several researchers in the Enterprise Resource Planning (ERP) systems area, but this has not been done in the area of APSs. Also, a survey by Olhager and Sellin (2003) reveals that about 45 per cent of the responding companies are planning, or considering, to extend their ERP system with a APS module. Five per cent already had an APS module implemented in the study, which makes APSs an emerging area where research is needed. This study intends to study if APSs show the same characteristics concerning successful implementations as ERP systems, regarding how to get implementation success.

2 Research goals

The overall purpose of this study is to study if the factors that are important for successful ERP implementations are also important for APS implementations. Since the question of successful implementation affects the decisions to be made before a possible implementation and the expectations that can be made on the effects of the implementation, this is useful knowledge. During the different implementation phases the importance of this study lie in the knowledge of which factors to put extra focus on to make the implementation a successful one.

3 Methodology

The stated purpose directly leads to the first aim of the study, which is to derive a set of factors important in ERP implementations. The second aim is to derive a set of effects concerning APS implementations, to study what can be classified as a successful implementation. The factors and effects are derived in a similar way, by reviewing literature in the fields of APSs and ERP systems, focusing on research on system implementations in these areas. Second, a multiple case study at four companies is conducted, where the factors and effects are studied. The selection of case companies are based on discussions with consultants, who suggested the four companies, grounded on the facts that all companies have used the same consultant firm and they have implemented APS modules from the same APS vendor. Also, the implementations concerned tactical planning with use of the Supply Chain Planner (SCP) module at all case companies.
The collection of data was done by semi-structured interviews at the case companies and with people working in the implementation projects. Typically the interviewed persons were supply chain managers, production managers or the like. Also interviews have been conducted with consultants involved in the implementation projects. The author has also, in some cases, had access to internal documentation from companies and information from their websites.

4 Frame of reference

The implementation of an ERP system is a complex process that affects an entire company (Davenport, 1998). An APS is a decision support system that, in most cases, adds functionality to an ERP system, as it extracts, treats and returns data to the ERP system. Still, many IT system implementations present similarities, but there have been no studies trying to pinpoint the applicability of ERP success factors on APS implementations, which is what this study will do.

4.1 Critical success factors

The word Critical Success Factors (CSFs) is used to label factors seen as important for success in several areas, as for instance project management or IT implementations. Concerning ERP systems there are several studies trying to explain if and why ERP projects are successful or not (Bingi et al., 1999, Teltumbde, 2000, Helo et al., 2008). To conduct this study, there is no need to explicitly examine a multitude of studies conducted on ERP CSFs, since the need is to see which factors that are derived, not how. Hence, after careful selection I choose to use two recently published studies to derive the CSFs.

First, a literature review by Dezdar and Sulaiman (2009) points to 17 CSFs derived from ERP implementation studies ranging from 1999 to 2008 (Table 1). They chose to divide the CSFs into five different categories; ERP technology, external expertise, ERP user, organization and ERP project. The first two of these concern the system and its environment, whereas the last three concern the adopting organization environment.
A second literature review, by Ngai et al. (2008) condenses 18 CSFs from 92 sub-factors found in the ERP literature (Table 2).

![Table 1](image1)

<table>
<thead>
<tr>
<th>Category</th>
<th>CSF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ERP technology</strong></td>
<td>Careful selection of ERP software</td>
</tr>
<tr>
<td></td>
<td>Software analysis, testing and troubleshooting</td>
</tr>
<tr>
<td></td>
<td>System quality</td>
</tr>
<tr>
<td><strong>External expertise</strong></td>
<td>Vendor support</td>
</tr>
<tr>
<td></td>
<td>Use of consultant</td>
</tr>
<tr>
<td><strong>ERP user</strong></td>
<td>User training and education</td>
</tr>
<tr>
<td></td>
<td>User involvement</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td>Top management support and commitment</td>
</tr>
<tr>
<td></td>
<td>Enterprise-wide communication and cooperation</td>
</tr>
<tr>
<td></td>
<td>Business plan and vision</td>
</tr>
<tr>
<td></td>
<td>Organizational culture</td>
</tr>
<tr>
<td></td>
<td>Appropriate business and IT legacy systems</td>
</tr>
<tr>
<td><strong>ERP project</strong></td>
<td>Project management and evaluation</td>
</tr>
<tr>
<td></td>
<td>Business process reengineering and minimum customization</td>
</tr>
<tr>
<td></td>
<td>Change management programme</td>
</tr>
<tr>
<td></td>
<td>ERP team composition, competence and compensation</td>
</tr>
<tr>
<td></td>
<td>Project champion</td>
</tr>
</tbody>
</table>

Table 1 Critical Success Factors (Dezdar and Sulaiman, 2009)

![Table 2](image2)

<table>
<thead>
<tr>
<th>CSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate business and IT legacy systems</td>
</tr>
<tr>
<td>Business plan/vision/goals/justification</td>
</tr>
<tr>
<td>Business process reengineering</td>
</tr>
<tr>
<td>Change management culture and programme</td>
</tr>
<tr>
<td>Communication</td>
</tr>
<tr>
<td>Country related functional requirements</td>
</tr>
<tr>
<td>Data management</td>
</tr>
<tr>
<td>ERP strategy and implementation methodology</td>
</tr>
<tr>
<td>ERP teamwork and composition</td>
</tr>
<tr>
<td>ERP vendor</td>
</tr>
<tr>
<td>Fit between ERP and business/process</td>
</tr>
<tr>
<td>Monitoring and evaluation of performance</td>
</tr>
<tr>
<td>National culture</td>
</tr>
<tr>
<td>Organizational characteristics</td>
</tr>
<tr>
<td>Project champion</td>
</tr>
<tr>
<td>Project management</td>
</tr>
<tr>
<td>Software development, testing and troubleshooting</td>
</tr>
<tr>
<td>Top management support and commitment</td>
</tr>
</tbody>
</table>

Table 2 Critical Success Factors (Ngai et al., 2008)
To compare these two reviews the factors found by Ngai et al. has been categorized according to the Dezdar and Sulaiman’s five categories (Table 3). This shows that the differences mostly concern definitions of factors. Still, three factors are mentioned by Ngai et al., which are not explicitly mentioned by Dezdar and Sulaiman and hence needs to be clarified. Two of these concern geographical attributes; national culture and country related functional requirements. These are to some extent included in the factor fit between ERP and business/process. The third factor not explicitly stated in Dezdar and Sulaiman’s study, data management, is incorporated in the factor software analysis and testing.

![Table 3 Comparison between the two CSF reviews](image)

Several other studies have found similar CSFs. Grabski and Leech (2007) derives 25 CSFs and with the result from a survey construct five control factors from the CSFs. They conclude that all five control factors are necessary, but none are sufficient for a successful ERP implementation. The CSFs found in the two reviews do not differ from Grabski and Leech’s result and they also coincide with other published studies (Al-Mashari et al., 2003, Umble et al., 2003), which is the reason they are found appropriate to use in this study.

The categories developed by Dezdar and Sulaiman are used as a base when selecting the CSFs to be studied; the specific CSFs are derived from both reviews, to get a comprehensive selection. First, the CSFs and categories concerning ERPs as such have been changed to concern APSs instead, which is a needed change. The CSF data management is included in the study instead of being just part of the factor software analysis and testing. The CSFs belonging to the category APS vendor and Use of consultant have been excluded, as they are included in the factor change management culture and programme. The CSFs chosen to be studied are listed in Table 4, where they are given numbers, to make them easier to identify. Also, the factors APS vendor and Use of consultant have been merged, as they are identical for the case companies in this study. In another study, they should be kept separate.
Table 4 Critical Success Factors chosen to study

In the following section, a brief description of the 18 studied CSFs will be made.

1.1 Country related functional requirements

This factor concerns the fact that cultural differences may lead to systems developed for one market might not fit other markets, for instance concerning interfaces, report formats and so on.

1.2 Data management

As the data quality and the data structure sets a reference for the data that is to be used by the system, it is important that this is validated and that the format is consistent.

1.3 Fit between APS and business/process

This has implications in the choice of system, as an organization should choose a system that fits the business practices, to minimize the need for customization.

1.4 Software development, testing and troubleshooting

Tests, troubleshooting and problem solving of systems before going live is an essential task, as well as the development of integration with legacy and other software.

2.1 APS vendor and consultant

This factor covers the choice of vendor and consultant, as it can be a critical issue for instance concerning system updates, support and user training as well as the customization tools and technical issues.
3.1 Appropriate business and IT legacy system

This factor states that the systems already present should fit the chosen APS.

3.2 Business plan/vision/goals/justification

Goals and an investment justification should, according to this factor, be clearly stated at the start of the project.

3.3 Communication

Communication is a factor looking at the clear and effective communication at all concerned levels in the organization.

3.4 National culture

The national characteristics are also partly included in organizational culture, but here it is considered a factor in itself consisting of things as basic values, beliefs and norms that distinguish inhabitants of one country from another.

3.5 Organizational characteristics

This factor concerns the experience of other IT or organizational projects of the same scale and focus.

3.6 Top management support

The support and involvement from top management as well as the allocation of valuable resources to the project are incorporated in this factor.

4.1 APS strategy and implementation methodology

The existence of a strategy for the implementation, stating if changes should be made to the organization and the processes or to the system is the most important issue in this factor.

4.2 APS teamwork and composition

This factor is about getting a project team together that possesses all necessary competences, both business and technical.

4.3 Business process reengineering

Some business process reengineering should be involved for the company to be able to utilize the functions that the system provides.

4.4 Change management culture and programme

The company’s ability to get employees to favour the change is incorporated in this factor, but it also concerns the training and education of users and employees on the system as such as well as on overall concepts and strategies.

4.5 Monitoring and evaluation of performance

This is a factor where the structured revision concerning the performance of the system during and after the project is in focus.
### 4.6 Project champion

A project champion is someone who has sufficient power and ability to promote the project throughout the organization.

### 4.7 Project management

The project management factor includes issues such as a clear and defined project plan and is often related to the consultants, as they tend to run the projects.

### 4.2 APS success

When studying experienced effects of APS implementations, there are several so-called success stories concerning APS implementations with focus on benefits for the companies. Some of the APS effects (as I chose to call them) are found in several studies, such as inventory level reduction, and some are just found in one study, such as the reduction of overtime in production. Only effects that are explicitly stated in published literature are included, to prevent misinterpretations. All studies included have concerned tactical planning to some extent and all effects could hence stem from the use of an APS at the tactical planning level. The APS effects found have been incorporated in this study, no matter how common they are in the APS literature as a whole. The found effects, with references, are listed in Table 5 below, where they also are categorized as tangibles or intangibles.

<table>
<thead>
<tr>
<th>Intangibles</th>
<th>Tangibles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real time overview of the Supply Chain</td>
<td>Reduced total cost</td>
</tr>
<tr>
<td>More synchronized production and demand</td>
<td>Improved forecast accuracy</td>
</tr>
<tr>
<td>More optimized product mix with regard to resources</td>
<td>Reduced inventory levels</td>
</tr>
<tr>
<td>Reduced non-value added activities in production</td>
<td>Increased customer service level</td>
</tr>
<tr>
<td>More stable system with less IT problems</td>
<td>Improved on-time-delivery</td>
</tr>
</tbody>
</table>

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<tbody>
<tr>
<td>Real time overview of the Supply Chain</td>
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<td>More synchronized production and demand</td>
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<tr>
<td>More optimized product mix with regard to resources</td>
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<tr>
<td>Reduced non-value added activities in production</td>
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<tr>
<td>More stable system with less IT problems</td>
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<tr>
<td>Reduced total cost</td>
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<tr>
<td>Improved forecast accuracy</td>
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<tr>
<td>Reduced inventory levels</td>
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<td>Increased customer service level</td>
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<tr>
<td>Improved on-time-delivery</td>
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<tr>
<td>Increased average sales price</td>
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<tr>
<td>Increased planning (and replanning) speed</td>
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<td></td>
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<tr>
<td>Reduced overtime in production</td>
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<tr>
<td>Less emergency transports between DC:s</td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>
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Table 5 APS effects with references

The question of success is not explicitly covered among these APS effects, as it is a more complex question that depends on expectations and goals. In this research the question of success will be based on the APS effects gained.
5 Case descriptions

The four studied cases all concern companies based in Scandinavia with a make to stock (MTS) production. All four are active in the food and beverage sector. The reason for choosing these companies is that they have gone through APS implementation projects and all of these projects have concerned implementation of a SCP module for tactical planning. Three of the companies have also implemented a Demand Planner (DP) module, whereas the fourth company already had such a module in use. All companies are considered process industries and are active in the food and beverage sector. All companies have implemented the same type of APS system and all have used the same consultant firm. Further details about the companies are given in Table 6 below.

<table>
<thead>
<tr>
<th>General</th>
<th>Alpha</th>
<th>Beta</th>
<th>Gamma</th>
<th>Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector</td>
<td>Food &amp; Beverage</td>
<td>Food &amp; Beverage</td>
<td>Food &amp; Beverage</td>
<td>Food &amp; Beverage</td>
</tr>
<tr>
<td>Turnover [EUR]</td>
<td>40 000 000</td>
<td>250 000 000</td>
<td>350 000 000</td>
<td>125 000 000</td>
</tr>
<tr>
<td>Number of employees</td>
<td>100</td>
<td>1 000</td>
<td>600</td>
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</tr>
<tr>
<td>Physical structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of production sites</td>
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<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Number of production lines</td>
<td>7</td>
<td>16</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Number of warehouses</td>
<td>1</td>
<td>4</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Products and production</td>
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<td></td>
<td></td>
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</tr>
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<td>Number of SKUs</td>
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<td>400</td>
<td>500</td>
<td>200</td>
</tr>
<tr>
<td>Type of production</td>
<td>MTS</td>
<td>MTS</td>
<td>MTS</td>
<td>MTS</td>
</tr>
</tbody>
</table>

Table 6 General description of the studied companies

5.1 Company Alpha

Before the implementation of an APS suite Alpha used an ERP system and several spread sheets to conduct planning and inventory control. Concerning forecasting, they used an APS DP module, but the forecasting was not seen as important by the company. The decision to implement a SCP module was based on the fact that a lot of time was spent on planning and the plans were changed frequently. Also, the planner, who had all the knowledge about how to use the planning solutions, was leaving the company, which meant that no one in Alpha would have the knowledge to conduct the planning. The goal of the project was hence to reduce the dependence on one person, to spend less time on planning and to conduct replannings less often. Also, a goal was to decrease the inventory levels and have products with longer shelf life left in store.

5.2 Company Beta

Before the APS implementation Beta used their ERP system, with aid from some proprietary systems and spread sheets, when conducting the tactical planning. The decision to implement a SCP module and a DP module were part of the decision to change the entire ERP system. The APS project, concerning tactical planning, was just a small part of the large ERP project. This meant that the implementation time increased as the APS project had to wait for the ERP project on several instances. Also, this fact affected the choice of vendor, as the APS had to be from the same vendor as the ERP. Because of the fact that the APS project was just a part of the larger project, Beta did
not have any specific goals for the APS project, it was all a part of the bigger goal, which was to simplify the systems settings and get homogeneity among the different diverse IT functions. The SCP model uses many constraints to make it fit into the company processes, so that the system behaves as Beta is used to.

5.3 Company Gamma

Before the APS project, the planning at Gamma was done by one person on each of their production facilities. This planning was done either using spread sheets or with pen and paper. The reason for initiating an APS implementation was that there was no communication about plans between facilities at Gamma. Also, there was no central planning, which also meant that thoughts about balancing the production over their production sites did not exist. The goals for the project were to utilize their warehouse capacity better, to improve the on-time delivery and to get a better overview over the processes.

5.4 Company Delta

Before implementing an APS, the planning at Delta was based on the yearly budget and conducted in spread sheets. The reason for implementing an APS was partly because the production results had been bad the previous years and the production manager felt that “something had to be done”. This coincided with promotional activities from their ERP vendor, concerning APS, which led to the decision to initiate an APS project. The goals were to get an overview over the processes and improve the on-time delivery. Effects from Deltas APS implementation are somewhat preliminary, as they just recently have begun to notice them.

5.5 Comparison concerning critical success factors

The CSFs were tested at the interviews. A company found having accomplished a factor well is marked with a plus sign (+), for instance if they have had good support from the top management. A company with a badly accomplished factor is marked with a minus sign (-), for instance if their data management was poorly handled. If the companies have neither a good nor a bad accomplishment it is marked with a zero (0). If there has been no information at all about the CSF in question, it is marked with n/a.
In the following section, a brief discussion on the 18 studied CSFs and the companies’ accomplishments on each of them is presented.

**Similarities concerning CSFs**

The CSFs *APS vendor and consultant* and *National culture* are marked as n/a, as all companies have used the same consultants and have similar national cultures, which make it impossible to estimate the achievements on those CSFs.

The CSFs where all companies have been marked with a plus (1.1, 1.3 and 3.1) all concern the systems respond to present company characteristics. The companies do not show any country related functional requirements that the APS can’t handle and the APSs are suitable to fit their existing systems and to incorporate their business processes.

The CSFs with constant negative achievements (3.2, 3.5 and 4.5) concern the goals, their fulfilment and the organizations previous experience in handling IT projects as these. None of the companies had any clearly stated goals in the beginning of the projects; they had some fuzzy goals, but nothing clearly stated in writing. Neither did they have any structured revision nor did any follow up on the performance during the projects. They all did follow up on external costs, but that was about it. Also, no company had any previous experience in projects such as these. The CSFs with differing achievements are discussed in the following.

**APS technology**

*Data management* (1.2) was handled ok in three companies, meaning that they had to put a lot of work into cleaning the data and checking it before going live, as they hadn’t done this in the beginning of the projects. The other company tried to implement their APS on data that wasn’t accurate, Gamma did this for several months, making the system provide plans that the company was not able to use.

The *software development, troubleshooting and testing* (1.4) was done sufficiently at two companies and insufficient at one. The fourth company is in between the others in their achievement.

<table>
<thead>
<tr>
<th>Category</th>
<th>Nr.</th>
<th>CSF</th>
<th>Alpha</th>
<th>Beta</th>
<th>Gamma</th>
<th>Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>APS technology</td>
<td>1.1</td>
<td>Country related functional requirements</td>
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<td>+</td>
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<td>1.2</td>
<td>Data management</td>
<td>0</td>
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<td>1.3</td>
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<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>Software development, testing and troubleshooting</td>
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<td>+</td>
<td>+</td>
<td>0</td>
</tr>
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<td>External expertise</td>
<td>2.1</td>
<td>APS vendor and consultant</td>
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<td>n/a</td>
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<td>n/a</td>
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<tr>
<td>Organization</td>
<td>3.1</td>
<td>Appropriate business and IT legacy systems</td>
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<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td></td>
<td>3.2</td>
<td>Business plan/strategy/goal/justification</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
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<td></td>
<td>3.3</td>
<td>Communication</td>
<td>+</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>National culture</td>
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<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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<td></td>
<td>3.5</td>
<td>Organizational characteristics</td>
<td>-</td>
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<td>-</td>
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<tr>
<td></td>
<td>3.6</td>
<td>Top management support</td>
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<td>+</td>
<td>+</td>
</tr>
<tr>
<td>APS project</td>
<td>4.1</td>
<td>APS strategy and implementation methodology</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td>4.2</td>
<td>APS teamwork and composition</td>
<td>+</td>
<td>-</td>
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<tr>
<td></td>
<td>4.3</td>
<td>Business process reengineering</td>
<td>+</td>
<td>-</td>
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<td>-</td>
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<tr>
<td></td>
<td>4.4</td>
<td>Change management culture and programme</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td></td>
<td>4.5</td>
<td>Monitoring and evaluation of performance</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>4.6</td>
<td>Project champion</td>
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<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
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<td>Project management</td>
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Table 7 Fulfilment of CSFs
**Organization**

**Communication** (3.3) is a factor looking at the clear and effective communication at all concerned levels in the organization. This is difficult to verify, but two companies seem to stand out from the rest with good communication throughout their projects.

Three of the companies had good support from their top management (3.6); the other did have some support, rendering them a zero.

**APS project**

Three of the companies had an *APS strategy and implementation methodology* (4.1) throughout their projects, stating if changes should be made to the company or to the system, the other company did not possess such a strategy, as questions as those were more ad-hoc based in that project.

The project teams (4.2) at two companies were put together in a way that took advantage of all necessary competences. At the other two companies the teams were lacking competence in some area.

Some *business process reengineering* (4.3) should be involved for the company to be able to utilize all functions that the APS provides. Only two companies has changed their organizations in order to be more efficient as part of, or in relation to, the APS project.

Three companies have had good achievement on the factor *change management culture and programme* (4.4), as they have had support for the change throughout the companies and also have had sufficient training and education. The other has had resistance to the change and insufficient training, rendering a negative achievement.

A *project champion* (4.6) promotes the project throughout the organization, which has been done at three of the cases.

The *project management* (4.7) has at two companies shown negative characteristics, at Gamma because of the lack of structure and project plans and at Delta because of frequent changes of project members, due to employees leaving the company. The other two have had ok project management, but nothing that stands out as good.

### 5.6 Comparison concerning APS effects

Concerning APS effects (Table 8); the companies have been assigned a plus (+) if there are evidence that they have achieved a positive effect. They would have been given a minus sign if the effect had shown negative characteristics, like for instance that the inventory levels had increased. This has not been the case, since no company has experienced any negative results in these areas. If the company had not been able to provide information about the effect in question, it would have been marked with n/a, but this is also not the case. If there are no changes to the studied APS effect that field is left blank.
Considering the achieved effects, three companies stand out with positive effects, Alpha, Gamma and Delta. These companies have achieved several positive effects from their APSs and two of them are very satisfied with both the systems and the consultants. The third, Gamma, is not satisfied at all, which should be assigned to the fact that they think that the consultants promised that the system would perform better and be easier to implement and use than what has been the case. Hence Gamma have the opinion that they have not been given what they bought. Still, the project as such has forced them to change their internal processes, which has given several positive effects. This is not primarily because of the APS, but according to interviews the changes had never been made without the pressure from the APS project.

Beta has the least positive effects of the four studied companies, but they are very satisfied with the system and with the consultants. The reason for them not achieving many positive results is their reluctance to change the internal processes, as the system at Beta has been modelled to behave as systems at the company always have, which is what they wanted from the start.

6 Discussion

A general overview of the four cases gives that more positive CSFs seem to lead to more positive effects, which is expected if ERP CSFs are applicable concerning APS projects. The exception from this is Delta, where the CSFs are not present to any great extent. An interview with the consultant revealed that although the system solution in the Delta project was good the project as such wasn’t. In a study such as this it is impossible to separate the project from the system, as they both are part of the solution provided at the companies. The consultant’s statement explains the CSF situation at Delta, but it also shows the possibility to get a good solution even with a bad project. Still, Delta had chosen an APS to fit their internal processes (1.3) and their existing systems (3.1) as well as their country related requirements (1.1). They had a project champion (4.6), promoting the system and they had support from the top management (3.6), which seem to be important factors.

Concerning the two factors business plans/visions/goals/justification (3.2) and monitoring and evaluation of performance (4.5) none of the studied companies had these factors present. The lacking of structured goals and justification, together with the non-existent monitoring of performance is not surprising as many companies tend to
measure a project’s success based on the cost in relation to the budget. The external cost of the project has been monitored in all cases, but this is not a CSF and should not affect the different projects’ success in terms of APS effects. Still, this study reveals that projects as these could be monitored more carefully by other than financial standards, as this would most likely improve the final results and effects.

The two companies with most CSFs achieved, Alpha and Gamma, have also shown many positive effects. Concerning Gamma, they are not satisfied with the system and the project, but still they have seen several positive effects. The inventory levels have actually not decreased at Gamma, but their warehouse capacity is scarce, which means that their goal is not to decrease inventory, but to have the right products in their warehouses. Since they now do have more of the right products and less of the wrong ones in their warehouses, the effect decreased inventory has been registered as achieved at Gamma. Also, they are not finished with the project and therefore more effects could show in the future.

The effects that none of the cases have verified, increased sales price, more stable system and less emergency transports between DCs is not surprising. Only one of the companies, Delta, experiences such extreme seasonal variations that they have to sell products with large discounts in the after season. Since they have not gone through an entire seasonal cycle with their APS, they have yet to discover if the average sales price might be affected. The system stability has never been an issue prior to the APS projects, since all companies used spread sheets or similar solutions, which can be considered stable. Also, the emergency transports are not a crucial effect, since none of the companies did operate that way before their APS implementations.

Which of the companies’ APS implementations that should be classified as overall successful is subject to discussion? Alpha have achieved many positive effects and are satisfied with the system, as have Delta. That would make those two successful. Beta have not achieved many positive effects, but their goal was to make the system behave as their old system did, which is what they have done. Hence, from Betas point of view it is a successful implementation, but from a holistic view the system should be able to support the company in getting more efficient, which would make Beta’s implementation less successful. Gamma is the opposite of Beta in this sense, as they have achieved several positive effects but are not satisfied, since they think that they were promised more by the consultants. This distinguishes two groups; the successful ones Alpha and Delta and the undecided Beta and Gamma.

The three CSFs they all have in common concern the APS system as such; country related functional requirements (1.1), fit between APS and business/process (1.3) and appropriate business and IT legacy system (3.1). An APS to fit both the existing systems and the company processes hence seem to be an important factor, and logically it should be.

Two other CSFs, present at the successful companies, worth mentioning are project champion (4.6) and project management (4.7). Having someone promoting the project throughout the company and also having support from the management considering resources and sheer interest seem to be important factors, as it can help facilitate the acceptance of the project at different levels at the company.
7 Conclusions

Some ERP CSFs seem to be applicable even concerning APS implementations. This study is a first step in finding a relevant base of CSFs to pay attention to during APS implementations, as these differ in magnitude from ERP implementations. A conclusion drawn from these four cases is that it is necessary to have a system that is able to incorporate the business processes and legacy systems, or be prepared to change these within the company. When this is achieved, support from top management and a project champion might be the thing that makes the project successful, provided that other issues are acceptably handled.

Since the results and conclusions stem from only four cases, the results are to be taken under careful consideration. The generalization will be limited to companies under the same conditions as the cases here, but one should also keep in mind that the results are verified in other published studies.

Practitioners and managers will get support from this study in their decisions concerning APS implementations. They will be able to use the results in deciding their project strategy and specifically deciding which factors to put extra focus on, during the implementation, to make the APS implementation a successful one.
8 References


