A Study of Production Planning in a Hospital Environment

Master’s Thesis in Logistics Management

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A study of Production Planning in a Hospital Environment

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Master’s Thesis

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Abstract

Production planning is a well used and developed activity in many of today's manufacturing and service companies in the pursuit of better meeting demand and creating profit. One of the areas that have not developed this activity in general very much is the hospitals. Historically, the production planning below the top sales and operations planning consists of manpower scheduling. The manpower scheduling however doesn't regard forecasts or the order stock in a structured way, at least not at the Urology department at Södra Älvsborgs Sjukhus which this thesis is based on. The scope is therefore in between the sales and operations planning and the hourly based manpower scheduling.

The thesis starts with a literature study to understand what knowledge is applicable to the hospital and later continues with a benchmarking which takes this one step further by attaining practical knowledge from an industry company. A study of the department builds the basis for understanding what factors are important to consider when production planning at the hospital and also how a forecast can be made in a relevant way. All of this is summarized and fitted in a production planning process and a practical tool with Microsoft Excel and its Visual Basic for Applications add-on.

The results show that standard processes for production planning, such as master production scheduling, production scheduling and capacity planning definitely can work in the hospital environment. These processes can add a structure and planning methodology to the hospitals production planning and also include important features that are needed to make production plans. Information given and summarized in these processes for the planner are patient visits and treatments, average waiting times, waiting lists, manpower and previous production plans. Information created are the actual plans and the expected outcome of these plans. Forecasts are created automatically by the tool, but only as a recommendation, not a final plan. The expected outcome is calculated based on up-to-date waiting lists, forecasts and the scheduling. On a master production scheduling level planning is made on a monthly perspective, with a horizon from 3-12 months. In the lower level production scheduling the perspective is instead daily, with a horizon of 3 months. This is expected to give a long-term planning perspective in order to adjust far ahead to demand and at the same time give a short-term perspective by creating the production schedule only 3 months in advance. The production schedule thereby makes sure that demand can be met on short-term perspective. On both levels there are capacity plans to make sure that production schedules are within limits of the departments capacity, both on a aggregated monthly basis and on a disaggregated daily basis.

It's concluded that forecasts on remittance alone can show the real need. Forecasts on previous patient visits or treatments are heavily affected by previous planning at the moment, planning that hasn't been adjusted to demand. Seasonal variations can therefore only be used for remittance forecasting, while average values and trends alone are usable for forecasting visits and treatments.

The thesis summarizes the results into an Excel workbook which is built according to the production planning processes and can be used continuously by just adding new data each month and consequently following through with the planning. These processes and the tool shall be managed by the department manager with aid from both the secretary and the managing nurse in order to create a fully working planning environment.
Acknowledgments

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Abbreviations and dictionary

Assemble-to-order  A type of production setting where products are assembled following a specific customer order.

Make-to-stock  A type of production setting where products are manufactured and kept as inventory before orders are received.

Make-to-order  A type of production setting where products are finalized (detailed manufacturing) following a specific customer order.

ERP  Enterprise Resource Planning. The overall planning system of the company/organization.

KPI  Key Performance Indicator. A measure of something that has a strategic value to the company/organization.

MRP  Material Requirements Planning.

Lean  A production philosophy that tries to minimize the usage of resources, from manufacturing to delivery of a product.

Outpatient  A patient that visits the hospital for diagnosis or treatment, but is not kept overnight.

Inpatient  A patient that visits the hospital for treatment and is hospitalized for days or even years in some cases.

Day surgery  A surgery that doesn’t require the hospitalization of the patient.

Waiting time  The length of time in days that a patient has been waiting for a visit or for a treatment.

Waiting list  The total amount of patients waiting for a visit or a treatment, including patient with and without an scheduled appointment.
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Chapter 1

INTRODUCTION

1.1 BACKGROUND

At Södra Älvsborgs Sjukhus it has been decided that production planning is to be implemented at most of the clinics. Previously there has not been any structured planning at all concerning the reception or treatment of patients. The capacity has instead been based on tradition without concern for the uneven flows of needs. Still today, personnel are planned first with the idea that the capacity is evenly distributed over days, weeks, months and years. After personnel has been scheduled the patients have been scheduled wherever there is capacity to receive them. This is not efficient when there are variations in the flow of remittance and when there is a need to shorten the queues. The decision has therefore been made by regional politicians to implement a production planning process that resembles the planning structure of the industry and where changes in capacity are made according to the demand.

The healthcare system in Sweden has been changed significantly during the last couple of years. From 2003 there has been a National Healthcare Guarantee with an aim to limit the waiting times for first visit patients. This guarantee was in the beginning only a recommendation to all regions, including a right for all patients to change healthcare region for their respective illness if the healthcare guarantee couldn’t be met. Since July 1 2010 this guarantee, has been changed into a fully working law meaning that Socialstyrelsen (The Swedish National Board of Health and Welfare) can take measure if the law is not met. There is also an incentive for the regions to commit to this law since there is an extra monetary bonus for the regions that can show records of following this guarantee. If the guarantee can’t be met the hospital has to pay for the care somewhere else. The law states that a patient has the right to get in contact with the primary care, either by visit or telephone, during the first day. The patient then has the right to see a general physician in the first 7 days after the first contact. No later than 90 days after the referral from the general clinic the patient has the right to meet a specialist doctor for consulting, and within an additional 90 days the patient has to be offered an appointment for treatment, i.e. surgery. Patients with cancer have an even shorter guarantee. A child with suspicion of cancer has the right to meet a specialist in 2 days and an adult with suspicion of cancer has the right to meet a specialist in 14 days. The overall guarantees can also be regionally different, but not longer than the national guarantee. Each hospital or clinic can as well have their own goals. The National Healthcare Guarantee is commonly described as 07-90090. Initially, there was a noticeable cut in waiting times and it appeared that this cut was due to improved efficiency of the resources [Larsson, 2011]. This shows that there still are ways to create better efficiency and improved working processes.

1.2 PROBLEM AREA

The problem is not that the workforce at the hospital is reluctant to using planning tools for scheduling. It is not either that they don’t understand the demand from the patients, they are well aware of various queues and queue times. The healthcare guarantee has more than ever shed light on knowledge about the present queues. During the last few years, queues have been shortened, not least at the department of this study. This has been done with overtime and additional extra hours during evenings. However, this is not a long term solution something else needs to be done to keep shortening the queues and to be prepared for future periods of high demand. The problem is therefore to find a workable solution to aid the planners in their attempt to shorten queues and adapt the workforce to the ever changing demand.
As of today there is no planning tool that aids them in understanding how the outcome of the scheduling will likely be. 

There also seems to exist a research gap in this area. Articles referring to healthcare and logistics most often relate to separate issues such as quality, new technology, lean and process improvement in a conceptual manner. No articles have either been found that relate the different levels of planning with each other. 

The important aim of this work is that the result of it has to be understandable and practical to work with, if it is ever going to be implemented in a functional way. Mattsson and Jonsson (2003) state that planning methods and planning systems can never work effectively if the user doesn’t understand the content and how it shall be used. It will be a goal of this work to leave the power with the doctors and nurses, but provide them with tools and data so that they can improve their accuracy in their planning to better meet customer demands.

Queues at this section have been significantly reduced lately by the use of over time, so the main issue of this work is not only to reduce queues. It is to investigate in the capacity usage so that queues at least doesn’t increase again and also importantly that the staff have a better knowledge of where and when to focus capacity. Being able to plan the capacity accordingly to demand create a more even environment for the staff and makes it easier to plan far ahead without risking large variations in demand. The population of Sweden is getting older though [Larsson, 2011], which means that with time, the queues will possibly increase, both because the group of customers will increase but also due to the fact that doctors increasingly become better at finding new diseases and treating them.

According to Elg et al (2009) there is an increased external pressure on leaders to focus on improvement work. Higher management decisions, patient pressure and decisions made by policymakers increasingly influence the healthcare managers. From the years 2003 to 2007 three different trends were identified; take-control logic, practice-based improvement and patient centeredness. This shows that the need for better tools and improved working processes are highly sought after in general.

1.3 PURPOSE

The purpose is to develop and suggest improvements for the production planning at the Urology department of the Surgery clinic. This includes finding a suitable way to make forecasts, understanding the demand of the patients, understanding historic outcome of the planning and understanding the needs of the department in terms of workforce for every service. After this basic purpose has been met, the purpose is to suggest a planning process and a planning tool that takes all these demands into account.

By combining theory, industrial knowledge and knowledge about the hospital this research aims to answer the purpose of this thesis.

1.3.1 Research Questions

The research questions are meant to offer a solution for the problem area described above and at the same time give a comprehensive image of this thesis.

1. How can a department use theory and knowledge from the industry?

2. What factors affect the planning decisions at the department?

3. How can we make a relevant forecast of the patient demand?

4. How can a planning process and planning tool be designed?

1.4 DELIMITATION

The focus of this report will be on the master planning and detailed planning level, including the capacity planning that is needed on these levels. The overall sales and operations planning and the underlying daily planning is not included in the report even though this very much affect the outcome of the production.

Figure 1.1 shows a planning and control system [Larsson, 2011], where the scope of this report has been highlighted. The structure of the figure is the base for the structure of this report.
Doctors especially are heavily involved in both examination, surgery and post care, however, the limitation is set to the team of staff at the reception where all the examinations are taking place. This includes the doctors and their responsibilities at the different departments and the nurses that work at the reception.

The knowledge of production logistics is divided in the areas of planning, development, cooperation, organization, management and control of a manufacturing company’s material flows and resources [Mattsson and Jonsson, 2003]. The material flows have though been disregarded in the report since it would have changed the report into something much broader and different from what it is now. However, since the material planning perspective is so present in manufacturing planning it’s difficult to avoid discussing this area when trying to understand manufacturing planning.
Chapter 2

THEORETICAL FRAMEWORK

This chapter starts with a general view of production planning, and then continues with the master production scheduling, production scheduling and capacity planning. Figure 1.1 shows the last three sections in a structured way. The chapter then continues with forecasting theory and ends with a section about known applications in today's healthcare planning. While the text books can aid in the general knowledge about production planning in the manufacturing industry, the journal article search on the other hand focus mostly on production planning theory and present applications in healthcare.

2.1 PLANNING FOR PRODUCTION

There is a split between the planning strategies whereby some organizations choose to plan capacity first while some plan materials first. There is of course a need to match the two plans. However, the beginning focus can be different [Mattsson and Jonsson, 2003].

- Material first – The materials are planned according to the prognosis or the actual demand, without regarding the capacity. An evaluation is then made to make sure that the capacity can meet this demand, if not, the material flows has to be lowered.

- Capacity first – The materials are planned according to the present capacity. If the capacity is too low or too high a judgment has to be made if something drastically can be changed.

The first alternative is the most common one in a market economy. This is due to the necessity of being consumer driven. This is because available capacity is not in advance given at all times and because material needs are normally a lot more complex than the capacity need. And by starting with the material planning it is possible to understand what the optimal capacity need is. The first alternative can be described as product and market oriented rather than production oriented as the second alternative [Mattsson and Jonsson, 2003].

A common system in the manufacturing environment these days is the MRP-system, or MRP II-system, where the latter is an enhancement of the first one. According to Mereode et al (2004) the disadvantage of MRP is that it doesn’t take available capacity into account. However, MRP II corrects this by using other functions such as demand forecasting, rough-cut capacity planning and capacity requirements planning. The working schedule of a MRP II-system is shown in Figure 2.1. According to Rhine and Jupp (1988) the three principal components manufacturing, marketing and finance aggregate their resources in this system into a manufacturing schedule designed to optimize the way in which the firm meets the demands.
Figure 2.1: MRP II, [Rhyne and Jupp, 1988].

Figure 2.1 therefore shows a process and a planning structure [Rhyne and Jupp, 1988] that is well used in the industry and might be very useful for the hospital environment as well. The following chapters discuss the relevant contents of this figure in relation to Figure 1.1 as shown before. In Figure 1.1 "Production Scheduling" can be compared to the "Detail Schedule" process in fig 2.1.

2.2 MASTER PRODUCTION SCHEDULING

The long-term planning, commonly known as sales and operations planning ("Production planning" and "Resource planning" in Figure 1.1), create a balance between the demand and the capacity of the organization. While the sales and operations planning is focusing on the volume of production and delivery, the master production scheduling is more focused on the mix between products in a certain product group.

The main difference is that the master production scheduling is on a more detailed planning level and working in a shorter planning horizon. The sales and operations planning create, in other words, a plan for in which the master planning has to work.

There are however some similarities between the two which sometimes calls for a joint planning under the name master planning, i.e. in an organization with few amount of products or where the planning horizon is not longer than a year [Mattsson and Jonsson, 2003].

The master production scheduling is sometimes divided into delivery planning and production planning. Those cover the plans for the amount of deliveries and manufacturing per period. The delivery plan is usually a combination of customer orders and the forecast. In a make to stock environment the delivery plan probably only consists of prognosis figures, while for make to order environment the delivery plan can be totally built up of actual customer orders. The production plan is for a make to stock environment made out of manufacturing orders only due to the fact that the manufacturing is more than the actual present demand. While for a make to order environment the production plan depends on both manufacturing orders and an available capacity to be able to deliver in a certain period. In the
closest time periods the planning depends on actual manufacturing orders, otherwise on the ability to deliver. However, if the customer orders queue is long it is possible to use only manufacturing orders [Mattsson and Jonsson, 2003]. Figure 2.2 shows one example of the relation between the delivery and production planning [Mattsson and Jonsson, 2003]. The relation is the same as on the sales and operations level while in the master planning the possibilities to modify the production planning is limited due limited capacity restraints. In the master planning, the planning horizon is shorter and planning changes are therefore more difficult to make. A change in the capacity then requires short-term adjustments, such as overtime and rearrangement of personnel. The delivery planning on the other hand has to be more flexible in the master planning due to continuous incoming orders and possible annulments.

![Diagram](image)

**Figure 2.2:** Delivery and capacity planning, [Mattsson and Jonsson, 2003].

A process of master production planning according to Mattson and Jonsson (2003) includes these steps:

- Make a forecast of future demand.
- Make a preliminary delivery plan from the forecast and known customer orders.
- Make a preliminary production plan from the delivery plan, with input from actual and targeted inventory levels and orders.
- Make a comparison between the plans and the possibilities to fulfill them to make sure that they are within limits.
- Adjust the plans if necessary.
- Make a decision.

This process, which creates a delivery plan and a production plan, and is the essence of the master production planning, has the functions of:

- Fulfilling the sales and operations plan.
- Being an agreement for the production function to fulfill the production goals and deliver the planned quantities.
- Being a link between the market function and the production function.
- Coordinating and controlling the material flows in, thru and out of the organization.
- Being a help to the sales and order receipt department for making their decisions.

Jacobs et. al (2011) discusses the same functions with saying that the master production schedule is the basis for making good use of manufacturing resources, making customer delivery promises, resolving trade-offs between sales and manufacturing and fulfilling the firms strategic objectives as reflected in the sales and operations plan. It thereby has the role of converting the disaggregated sales and operations plan into a specific manufacturing schedule. In a more detailed manner Jacobs et al (2011) states that the
The master production schedule provides information by which sales and manufacturing are coordinated. The master production schedule has a function to show when products will be available in the future, thereby providing the resources for sales to know when delivery can be promised to customers. This information is valid as long as the manufacturing is executed according to plan. Otherwise, trade-offs have to be made and these will be made with the master production schedule acting as a basis for this decision. Table 2.1 below combines Figure 22 with the process described above and shows the main steps and differences between make to stock, assemble to order and make to order during the master production scheduling.

<table>
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<td>Planning objects are products</td>
<td>Planning objects are product models</td>
<td>Planning objects are product types</td>
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<td></td>
<td>Forecast must go beyond the planning horizon</td>
<td>Forecast must go beyond the planning horizon</td>
<td>Forecast not always possible</td>
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<tr>
<td>Preliminary delivery plan</td>
<td>&quot;Easily&quot; made from prognosis since delivery is from stock</td>
<td>Forecast consumption must be used</td>
<td>Forecast consumption must be used</td>
</tr>
<tr>
<td></td>
<td>Plan considers product models</td>
<td>Plan considers product types</td>
<td></td>
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<tr>
<td>Preliminary production plan</td>
<td>Created from the preliminary delivery plan and set inventory levels</td>
<td>Created from the preliminary delivery plan (for near future) and prognosis (for the last part of the horizon) if possible</td>
<td>Capacity can perhaps only be copied from sales and operations plan or the available orders</td>
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<td></td>
<td>The decision is used for material planning and to control the production</td>
<td>The decision is used for material planning and to control the production</td>
<td>The decision is used mostly for securing capacity</td>
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It is also important to understand that the master production schedule is in fact a plan that has to be followed to the extent that is possible. Forecasting is a part of the input of the master production schedule. However, the output is a decision that is affected by the forecast, not equal by necessity. According to Jacobs et al. (2011) the master production schedule also has to be in terms that relate to a producible product, i.e. not in terms of money. The production environment can highly affect the choice of unit.

An example of a master production schedule will now be discussed. The schedule involves variables that are specific to the environment, which means that the example doesn't cover any general situation, instead it's suppose to give an insight of the main parts of a master production schedule. Table 2.2 shows the example. Previous to the plan there is an on-hand stock (15) which acts like a buffer for the first period. Forecasting is the amount of orders that are believed to be produced, while orders are the actual customer demand in each respective period. Projected available balance is the on-hand inventory from previous period plus a possible planned production, minus the forecast of the present period. Available-to-promise is the on-hand balance from previous buffer (for first period) or the planned production amount.
(following periods) minus the total amount of orders until next production.

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<th></th>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast</td>
<td></td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Orders</td>
<td></td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Projected available balance</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>18</td>
<td>10</td>
<td>24</td>
<td>19</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Available-to-promise</td>
<td></td>
<td>5</td>
<td>17</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Master production schedule</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The available-to-promise can also be calculated cumulatively which means that it’s the sum of previous available-to-promise plus planned production minus the total amount of orders until the next planned production. This technique adds up the total amount of products that can be promised for delivery within the whole time horizon.

2.2.1 Planning Parameters

Behind the creation of a master production schedule there are a couple of planning parameters that needs to be considered:

**Planning object**  In an environment of make to stock the planning object is most likely the end product. On the other hand, if an organization manufactures to order it is not possible to plan for products, instead they would choose product categories. This is due to the fact that they cannot know what the customer will order [Mattsson and Jonsson, 2003].

**Planning unit**  In an environment of make to stock the planning unit probably is stock unit, while if it is make to order the unit is probably sales unit since they won’t have any finished inventory [Mattsson and Jonsson, 2003].

**Planning horizon**  The planning horizon of the master productions schedule has to be longer than the accumulated lead time for a product. If a planning window of for example 5 weeks is wanted and the lead time for a product is 10 weeks, then the production planning horizon should be 15 weeks. It is usually one half to a whole year according to Mattsson and Jonsson (2003).

**Period length**  If the production planning consists of available capacity a week is usually a suitable length, while if the production planning consists of manufacturing orders it is more suitable to use length of days. It is also possible to use different period lengths for different periods, i.e. weeks for the first month, month for month 2 to 6 and quarters for month 7 to 12 if the planning horizon is 12 months [Mattsson and Jonsson, 2003].

**Time limits**  In an automated environment it is useful to have time regulations for creating new production plans and for re-planning already made plans. A part of the schedule is sometimes frozen, which means that no changes in the frozen period are allowed. Time fencing is another concept, an extension of the freeze concept. Two common fences are the demand time fence and the planning time fence. During the demand time fence changes are usually not allowed. Between the demand time fence and the planning time fence changes can only be made by management, who have to make trade-offs to solve the problem. Beyond the planning time fence any changes can be made by the master production planner [Mattsson and Jonsson, 2003].

**Damping techniques**  A problem with ERP-systems, when letting them automatically control orders, is that there is a possibility that they will re-plan orders in an attempt to create better solutions, but instead creates a domino effect of changes. If the system is too sensitive it’s therefore necessary to have one or more dampening techniques in the system [Mattsson and Jonsson, 2003].
2.3 PRODUCTION SCHEDULING

The activities at this level can normally be described as the function in the company that put the previous plans at higher levels into action. Mattsson and Jonsson (2009) describe this level as one part order planning and one part capacity requirements planning. A large part of this level is therefore the material planning during the order planning phase which is not that interesting in this thesis. It involves strategies of material replenishment such as re-order point systems, periodic ordering systems, run-out time planning and material requirements planning. In the context of this report it is more interesting to study the capacity requirements planning. This will however be done in section 2.4 instead due to pedagogic and structural reasons.

What can be said about the production scheduling in relation to this thesis is that it has a shorter planning horizon and in most cases consider specific products. The master plan provides the gross requirement data to the production scheduling and is therefore the driver of all the detailed activities [Jacobs et al, 2011]. Another related issue that is both present in material and general planning is the concepts of pull and push. It is common to divide the company strategies between push and pull strategy, or both. Push strategy is a type of process where the production actor decides production without an order from the customer (or the next step in the process). Pull strategy is the opposite process, where production is only initiated by an initiative from the customer, or the next actor in the production process. It is not though clear that a certain material planning method is leaning towards a push or pull strategy, rather it depends on how they are used. For example, a re-order point system can be used by the consuming unit to order material which sets it to a pull strategy, while the same system also can be used by a material planning unit to order material for stock which sets it to a push strategy [Mattsson and Jonsson, 2003].

2.4 CAPACITY PLANNING

Capacity planning is a part of all planning levels but changes in depth due to planning horizon and the ability to plan for different horizon lengths. On the master planning level this means that capacity planning usually is based on planned production volumes while for some it’s based on actual production orders. Since the planning horizon is shorter on this level compared to the sales and operations level the ability to modify the capacity is therefore more limited, at least in terms of the total volume. According to Jacobs et. al (2011) the capacity planning on the master planning level is a rough-cut capacity planning that involves an analysis of the master production schedule to discover bottlenecks in the existing manufacturing resources. If capacity adjustments require a long time to be implemented, then it’s important to have a long planning horizon [Mattsson and Jonsson, 2003].

While the sales and operations planning and the master production scheduling works in the long range capacity planning, the production scheduling works in the medium range capacity planning as Jacobs et. al (2011) describes it, see Figure 2.3. In the short range capacity planning shop-floor systems and vendor systems has its scope. The scope of this report is also highlighted in Figure 2.3.
While Jacobs et. al (2011) state that this structure is a useful distinction, the time dimension can vary substantially from company to company. The purpose of the capacity planning is firstly to calculate the capacity needs for understanding the optimal capacity. If the available capacity is not equal to the capacity need, changes might have to be considered. Capacity planning is therefore used for balancing the available capacity with the capacity need. Having an available capacity means that there is cost, whether they are used or not and there will be a fall in income if the capacity doesn’t reach the levels of demand. An insufficient capacity quickly leads to a degradation of delivery performance, escalating work-in-process inventories and frustrated manufacturing personnel [Jacobs et al, 2011].

Capacity planning involves both volume and time, and according to Mattsson and Jonsson (2003) there are usually two capacity types:

- Volume capacity: The measure of how much capacity, in any given unit, that a working unit can perform per time period.
- Throughput capacity: A measure of how many hours per period that can be used for finishing a certain operational process.

The volume capacity is the interesting unit when planning the capacity. It is calculated on the production unit and is usually measured in expected available man hours per period or equipment hours per period. The environment decides if man hours or equipment hours, or any other appropriate unit, should be used. In the search of calculating the capacity need it is necessary to translate the production amount to a variable that is reflecting the needed work. Another part in calculating the capacity need is to define in what periods the need is located depending on through put times and delivery time. These two problems need to be solved for calculating the capacity need. The ERP-system usually has operation times stored in the system for calculating the need and it is important that they are based on actual believed operation times [Mattsson and Jonsson, 2003]. For different production units this can be calculated with equation 2.1:

\[
\text{Calculated operation time} = \frac{\text{Standard time for operation}}{\text{Effectivity factor}}
\]  

(2.1)

An important consideration in capacity planning is that demand might not be the same at all times, it might follow some available prognosis or perhaps surprise everyone involved. A make to stock environment
can to some extent increase or decrease its inventory levels and a make to order environment can to some extent adjust its lead times. However, this might not be enough and as a consequence the capacity has to be adjusted. There are two strategies for situations where the capacity has to be adjusted:

- **Lead-strategy**: A strategy where the capacity increases or decreases before the capacity need meet the level of the available capacity. The need pushes the capacity in the same direction as the need is pointing and the capacity is always larger or smaller depending on this direction.

- **Chase-strategy**: A strategy opposite to the lead-strategy, the need pulls the capacity in a reactive phase.

Even though the capacity can be adjusted and set to different levels it does not mean that it has to be fully used at all times. Two main strategies for capacity usage exist according to Mattsson and Jonsson (2003):

- **Even capacity**: The capacity is set to a static level with the inventory acting as the leveling variable.
- **Adjusted capacity**: The capacity is at all times adjusted to the changing demand.

In general it is common to use a combination of the two strategies and to take use of the inventory or longer lead times in an attempt to reduce the need of adjusting the capacity usage [Mattsson and Jonsson, 2003]. Jacobs et. al (2011) defines these two strategies as leveling (even capacity) where the production is held constant and chase (adjusted capacity) where the production follows the actual demand.

When working in the master productions scheduling and production scheduling phases there are four possible situations during the capacity planning. Figure 2.4 shows the different situations, where an ideal situation is when you have both accumulated agreement (total capacity match capacity need) and periodic agreement (total capacity match capacity need in each planning period). The accumulated capacity is best adjusted in the master planning since this is a question about volume, while the periodic agreement is better adjusted in the detailed production planning since this involves the mix of capacity and for a shorter planning horizon [Mattsson and Jonsson, 2003].

<table>
<thead>
<tr>
<th>Periodic agreement</th>
<th>Ideal capacity need</th>
<th>Increase/decrease capacity and/or capacity need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Re-distribute capacity and/or capacity need</td>
<td>Increase/decrease capacity and/or capacity need</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

**Figure 2.4: Capacity planning, [Mattsson and Jonsson, 2003].**

Capacity planning involves both calculations of available capacity and capacity need and there are many possible capacity and strategies to use. However since the available capacity and capacity need can and should be somewhat easy to calculate at the clinic during the first time of production planning, the theoretical framework will not go deeper into this area than discussing the basics of capacity planning techniques. Summarizing the historic data of overall production and capacity should be enough. For the master plan level Jacobs et. al (2011) define capacity planning using overall factors as one of the simplest techniques in the master plan level. An example is shown in Table 2.4. The input comes from the master production schedule in Table 2.3.
Table 2.3: Master production schedule, [Jacobs et al., 2011].

<table>
<thead>
<tr>
<th>Master production schedule (in units)</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>33</td>
</tr>
<tr>
<td>B</td>
<td>17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total direct labor in standard hours/unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
</tbody>
</table>

Table 2.4: Capacity planning using overall factors, [Jacobs et al., 2011].

<table>
<thead>
<tr>
<th>Work center</th>
<th>Historical Percentage</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>60.3</td>
<td>37.87</td>
<td>37.87</td>
<td>37.87</td>
<td>37.87</td>
<td>37.87</td>
<td>37.87</td>
<td>37.87</td>
<td>37.87</td>
</tr>
<tr>
<td>200</td>
<td>30.4</td>
<td>19.09</td>
<td>19.09</td>
<td>19.09</td>
<td>18.86</td>
<td>18.86</td>
<td>18.86</td>
<td>22.72</td>
<td>22.72</td>
</tr>
<tr>
<td>300</td>
<td>9.3</td>
<td>5.84</td>
<td>5.84</td>
<td>5.84</td>
<td>5.77</td>
<td>5.77</td>
<td>5.77</td>
<td>6.95</td>
<td>6.95</td>
</tr>
</tbody>
</table>

| Total required capacity | 62.8 | 62.8 | 62.8 | 62.05 | 62.05 | 62.05 | 74.75 | 74.75 |

The total required capacity is the sum of each production unit (product) times each respective hours/unit. This number is then divided among the work centers corresponding to their anticipated capacity, which is derived from the company’s accounting records [Jacobs et al., 2011]. These numbers can then be compared with the available capacity to see if capacity need and available capacity match or is in need of some sort of adjustments.

For organizations that use a detailed material plan, capacity requirements planning (CRP) is possible to use. This plan is linked to the material requirements planning (MRP) system and is created in an automated time-phased environment. Detailed capacity planning is however very detailed in terms of time and production functions and is not appropriate because the clinic environment, as later shall be seen, is a very flexible production facility dealing with patients and not materials. According to Jonsson and Mattsson (2003) CRP is working directly with manufacturing orders and this method is primarily used in planning situations where the need for great precision is high. The method also has its best advantages in environments where the setup time is long and you have large and varying order quantities.

### 2.5 FORECASTING

Mattsson and Jonsson (2003) describe the purpose of forecasting well by saying that:

“To be able to make decisions about the future in a qualified way you need information and estimations of how the future organization might be affected and be developed.”

They continue with stating that even for decisions that affect activities today, it’s necessary to understand how these affect the future. According to Jacobs et al (2011), forecasting information can come from many sources. They can have different levels of aggregation and incorporate different assumptions about the market that needs evaluation before it can be used for planning and control. Mattsson and Jonsson (2003) also define it as a prediction of external factors that may affect the organization but still can’t be controlled by the organization. Price setting is one of the exceptions that may affect the prediction outcome.

Forecasting usually affects the planning levels of sales and operations planning, production scheduling and production scheduling according to Mattsson and Jonsson (2003) but is different depending on the level. For example, on the master production scheduling level the forecasting object could be product model while on the production scheduling level it could be down to specific products and materials. The forecasting, on a tactical and operative level, generally concern predictions about the demand and some examples of areas of where the forecasting has an input are [Mattsson and Jonsson, 2003]:

- What capacity of personnel and equipment do we need to meet the demand of next year?
• What quantities of article X do we need and can we use as an underlay for supplier agreements?
• For how long will the inventory be enough and when do we need to re-procure?

There are also different kinds of forecasts; they can either be independent or related. A related forecast has a direct relation to another article, i.e. sub-parts to an end product. General demand forecasting is usually though intended for independent levels.

Three main types of patterns can usually be seen; random variation, trend variations and seasonal variation. These can be traced by historical demand, which should be the foundation of forecasting since demand is the variable that we want to forecast. This is not always easy though, because there is usually a difference between demand measurements and actual demand [Mattsson and Jonsson, 2003].

The period length of the forecast heavily depends on the usage of the forecast, i.e. if they are used for production planning they could have a length of a month, while if they are used for a yearly decision they could have a length of one year. The forecast horizon also depends on the usage. However, a longer horizon also means that it’s increasingly difficult to avoid forecast errors.

It’s important to also differ between a plan and a forecast. A plan is an adapted and agreed forecast which reflects the limitations and ambitions of the organization [Mattsson and Jonsson, 2003].

2.5.1 Methods

There are generally three types of methods [Aronsson, Oskarsson and Eladahl, 2009] that forecasting can be based on:

• Methods based on cause relations
• Predictions by experts
• Methods based on historic data

Forecasting methods where a subjective judgment is the primary ground for data has been used unknowingly for a long time at the hospital and will therefore not be treated in the report. Neither will methods based on cause relations be treated because there are no obvious relations except the variations of inhabitants in the area. Instead, different variations of calculation methods based on historic data will be discussed in this section and then all of the three methods will be taken into account in the analysis chapter. According to Segerstedt (2009) it is often to suggest that the choice of method is kept at a simple level, because it’s then easier to understand how large the error can be.

With the historical data it’s possible to identify a possible pattern of the demand. Even, cyclic, trend and random are the most common patterns. The pattern can then affect the choice and modification of method. Two well known methods are the Moving average and the Exponential smoothing.

Moving Average The method uses the last periods previous to the forecast, in the amount that is reasonable. Using many periods means that the forecast value will change slowly and not react much with random values. Using few periods means that the forecast will reflect random values to a greater extent. The equation will be [Mattsson and Jonsson, 2003]:

\[ P_t = \frac{X_{t-1} + X_{t-2} + X_{t-3} + \ldots + X_{t-N}}{N} \] (22)

Where \( P_t \) = forecast for period t and \( X_{t-1} \) = historic data for period t-1.

Exponential smoothing This method instead calculates a value that is based on historic data but where old values have less significance. The weighting is decided by the value of alpha which can differ between 0 and 1. A low value means slower reaction to changes while a high value gives the last period great significance. The equation will be [Mattsson and Jonsson, 2003]:

\[ P_t = \alpha \cdot X_{t-1} + (1 - \alpha) \cdot \alpha \cdot X_{t-2} + (1 - \alpha)^2 \cdot \alpha \cdot X_{t-3} \ldots \] (23)

where \( P_t \) = forecast for period t, \( X_{t-1} \) = historic data for period t-1 and \( \alpha \) is a number between 0 and 1.
Regression analysis  Another method is the regression analysis, which can be defined as the functional relationship between two or more correlated variables [Jacobs et al, 2011]. Linear regression analysis refers to the specific case where the relationship between variables forms a straight line. According to Jacobs et al (2011), linear regression is very useful for long-term forecasting of major occurrences and aggregate planning. This method can be used for both time series and for causal relationships. Linear least squares method is one type of regression analysis where the equation tries to fit a line of data that minimize the sum of squares of the vertical distance between each data point and the corresponding data point on the calculated line. The least square equation for linear regression is:

\[ Y = a + b \cdot x \]  

(24)

where

\[ a = \bar{y} - b \cdot \bar{x} \]  

(25)

and

\[ b = \frac{\sum x \cdot y - n \cdot \bar{x} \cdot \bar{y}}{\sum x^2 - n \cdot \bar{x}^2} \]  

(26)

where \( a \) = Y-intercept, \( b \) = slope of the line, \( \bar{y} \) =average of all y's, \( \bar{x} \) =average of all x's, \( x \) = horizontal value at each data point, \( y \) = vertical value at each data point and \( n \) = number of data points.

To adjust for trends and especially for production planning that requires long term forecasts, the most recommended method [Mattsson and Jonsson, 2003] is

\[ P(t + 1 + n) = PG(t + 1) + (n - 1) \cdot T \]  

(27)

where \( PG(t+1) \) = the forecast without trend or seasonal component, \( n \) = the nth period and \( T \) = \( X_t - X_{t-1} \) (Additive trend).

Adjustment for seasonality can be made by calculating the seasonal index:

\[ S(t) = D(t)/D(m) \]  

(28)

where \( S(t) \) = seasonal index, \( D(t) \) = actual demand in period t and \( D(m) \) = average demand for all periods.

The index is adjusted so that the sum of all indexes is equal to the amount of periods. Before any forecasting calculations can be made, the old data for actual demand has to be cleared for seasonal variation.

\[ DR(t) = \frac{D(t)}{S(t)} \]  

(29)

where \( DR(t) \) = Demand without seasonal affect for period t, \( D(t) \) = Actual demand for period t and \( S(t) \) = Seasonal index for period t.

The demand without seasonal affect can then be used to calculate a forecast that is clear of seasonal affect. The forecast with seasonal adjustment can then be calculated with the equation:

\[ P(n) = PG(n) \cdot S(n) \]  

(2.10)

where \( P(n) \) = forecast for period n, \( PG(n) \) = forecast without seasonal affect for period n and \( S(n) \) = seasonal index for period n.

To be able to compare different methods, it’s interesting to calculate the standard error of estimate [Jacobs et al, 2011]:

\[ S_{ys} = \sqrt{\frac{\sum(y_i - Y_i)^2}{n - 2}} \]  

(2.11)

where \( y_i \) = y value at each data point, \( Y_i \) = value of least square equation at each data point and \( n \) = number of data points.
2.6 APPLICATIONS IN HEALTHCARE

According to de Vries et al (1999) a hospital is not a manufacturing organization, but a special kind of service organization. Healthcare and manufacturing organizations are confronted with similar challenges such as increased complexity of processes by shorter lengths of stay of patients, the use of new technology and increased specialization, need for efficient utilization of resources and reduction of costs, increased pressure to improve the quality of services and the need to control workload of nursing staff and other personnel. De Vries et al (1999) continue with the major differences with a manufacturing environment:

- Manufacturing organizations focus on goods flow control while the process of healthcare organizations are represented by flows of patients and where the flow of materials are secondary.

- In healthcare there is no price-performance mechanism.

- Healthcare organizations do not have a simple line of command structure, but are characterized by a delicate balance of power between different groups, each of them having ideas about production performance.

- The key operators in the core process are highly trained professionals (medical specialists) who generate requests for service (orders) but also participate as key operators in delivering the service.

- Care is not a commodity that can be stocked; the hospital is a resource-oriented service organization.

The conclusion of de Vries et al's (1999) work is that a framework for approaching hospital production control is necessary. However, the unclear definition of concepts of products and processes, and the fact that there is a high variability in practice between specialists it's not possible to apply the standard production control concepts. However, elements of these approaches can be used if local conditions are accounted for.

According to Rhine et al (1988) the comparison between manufacturer and hospital would look like Table 2.5.

Table 2.5: The difference between manufacturing and hospital environment, [Rhine and Jupp, 1988].

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td></td>
</tr>
<tr>
<td>• Production begins with receipt of a customer order.</td>
<td>• Services are provided based on patient and mission.</td>
</tr>
<tr>
<td>• Demand for finished goods is primarily independent.</td>
<td>• Demand for services and materials is primarily independent.</td>
</tr>
<tr>
<td>• Bill of material is a minimum-level bill that does not emphasize assemblies or subassemblies and their relationships.</td>
<td>• Bill of labor is a singel-level listing of labor resources required.</td>
</tr>
<tr>
<td>• Unexpected demand occur with a constantly changing product mix.</td>
<td>• Emergency and urgent admissions occur with a fluctuating case mix.</td>
</tr>
<tr>
<td>Process</td>
<td></td>
</tr>
<tr>
<td>• Complex routings across different work centers may occur.</td>
<td>• Services are provided by many ancillary departments.</td>
</tr>
<tr>
<td>• Assembly operations for a particular product tend to flow in parallel and not sequentially.</td>
<td>• The variety of services to be provided do not necessarily occur in a fixed sequence.</td>
</tr>
</tbody>
</table>
Many of the articles found during the literature review relate to capacity in crisis, i.e., influenza and pandemics, and the everyday patient flow in a common environment. The articles that can be found in the area of healthcare forecasting are usually limited to crisis and deceases as well. Capacity wise some also deal with material planning and the learning’s that healthcare can obtain from new supply chain strategies and tools such as Lean [Jakobsson, 2009], ICT [Xiong and Shaligram, 2007] and RFID [Kumar, Dieveney and Dieveney, 2008] [Bendavid, Boeck and Philippe, 2010].

It also shows that many of the tools used for today’s healthcare improvements regard other things than capacity planning and patient needs. A case study of six departments was made by Jonsson and Larsson (2008) which showed that only one department consciously used a method of improvement, in this case process orientation. Four different methods were widely used; eliminating waste, standardizing, flow mapping and cooperation in the department. Matching capacity and demand was found to be used unconsciously, but not widely. The authors discuss even production, a method from the Toyota Production System where the variation in the production lines is reduced, as a method that has seen to have potential in the healthcare. The target would then be to produce the same quantity every month by using a flexible working force that can transfer to other production lines when necessary.

2.6.1 Meeting the demand

Waley and Stein (2006) describe how queues appear even at clinics where there is no long-run capacity shortage. They state that variation in demand is to a large extent introduced by a bad planning process. The article is focusing towards acute clinics but also mention that these experiences and methods apply to elective care. They proposed a number of ways to reduce the impact of variation on system performance:

- Really understand demand by forecasting
- Maintain the right capacity plans to meet demand
- Understand how the system introduces variation (i.e., by scheduling)
- Split the demand around processes (i.e., reduce number of steps and waiting opportunities)
- Design processes to absorb variation (i.e., take a “whole systems” view and not a subcomponent view)
- Look at capacity yield losses (i.e., set an expected date of discharge to make the process more deterministic)
- Use process control measures to understand variation (i.e., use statistics)

According to Silvester et al. (2004) the problem is rarely that there is a low capacity in the system. There is neither a correlation between waiting times and patient demand. There is typically no correlation between organizational capacity and patient waiting times. The primary cause of queuing in the NHS is instead the mismatch between variation in capacity and demand. Understanding the capacity and demand at a macro level, simplifying the process, segmentation of patients and reducing the variation of demand and capacity are some of the key steps for solving the issue of mismatch between capacity and demand.

Recently, there seems to have been an increase in the use of lean principles as a way to decrease queues and waiting times. This is an interesting path, however, it’s most commonly used for decreasing the queues and not to aid in the planning of staff. Some other ideas to reduce waiting lists have been proposed by Eriksson et al (2011). They found that reduced capacity was not the main issue of long waiting lists, it was instead found that emphasis should be on properly understanding and managing patient flows, acquiring knowledge about theories and methods to improve accessibility, and to match demand and capacity.

Already in 1998 Landstingsförbundet (a former Swedish member organization and employer) organized a pilot project with influence from The Institute for Health Care Improvement (IHI) in Boston and their project called “Breakthrough Series Model”. In this project, one of the strategies was to match capacity and demand. The strategy consisted of 7 concepts:

- Anticipating demand with greater aim – Know the statistics
- Even out variations – Schedule control visits when more important visits have less demand.

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1 Can be found in Swedish at www.vantetider.se/forbuettingsarbete/landstingsbank/dokumentbibliotek/processutveckling
- Adjust staff by predictable demands – Adjust after knowledge, vacation is not allowed during peak periods.
- Identify and remove bottlenecks
- Reduce the queue – Extra reception for a short period
- Use available resources with flexibility – Use specialist competence even for non-complicated cases
- Have alternative solutions at hand if the plan is not met – Be able to fill the spot with a new patient on short notice

Most results from the project were positive, mostly displayed with shorter waiting lists and queue times, but increased amount of operations could also be seen by one team that focused on this work.

Larsson (2011) has researched how planning and control impacts patient waiting times at a surgery department by taking theory from the manufacturing industry and applying it to the departments operation environment. The research showed that the group of patients treated reflected the available capacity instead of the actual patient demand. The focus was usually set to short-term planning which resulted in "fire-fighting" measures, instead of focusing also on the long- and medium-term planning to create a better balance. While investigating the actual planning processes it was found that the general planning and control system, as often used in the industry, could contribute in four main areas to the planning of the surgery clinic; the planning perspective of the planning process, the balance of planning focus between upper and lower levels, the integration between planning levels and the use of planning tools that support awareness of the patient demand. Larsson (2011) generalize her work to also include non-surgery departments, stating that the results are applicable to similar environments experiencing varying patient inflow.

Bamford and Chatzislas (2009) believes that a focus on capacity on a micro (departmental) level is wholly appropriate for healthcare operations. They also believe that this can make a direct contribution to the ability, for both department and the organization, to achieve and maintain its quality and cost objectives.

At Sahlgrenska University Hospital in Gothenburg, the work of better healthcare planning has started and even been implemented to some extent. Out of the hospitals 75 departments a master planning has been implemented at three of them. All of them will not implement master planning, but perhaps at least 60 more. The implementation is planned to be finished by the summer of 2012. The master planning implementation is the base for creating faster and more even flows. It’s the base for achieving control of the processes. Then, after while there will be improvements in setup times, quality, working flows, buffers and smaller batches. Figure 2.5 shows the master planning process that has been implemented in three of the departments.

![Diagram of master planning process](image)

**Figure 2.5: Master production scheduling process at Sahlgrenska** [Levi Siljemyr, Sahlgrenska]

At Skaraborgs Hospital in Skövde, which is also located in the Västra Götaland Region together with Södra Älvsborgs Hospital and Sahlgrenska University Hospital, they have started the production planning process at one clinic by looking at the available information about processes and the historical data, and found that these are seldom adequate. There is a lot of statistics but the problem is that one patient cannot be followed during his or hers process at the hospital. Statistics are difficult to find and not in the way they are needed for the production planning process. The problem with today’s planning is that no planner knows the demand. There are no statistics for where a remittance end up and what becomes of it. The problem is also that there is no follow-up in the planning process, which means that historical

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2Levi Siljemyr, Logistician at Sahlgrenska, e-mail conversation 2011-02-03
capacity, demand and possible queue building are not understood. Perhaps one of the most interesting stand points is that demand variation problems mostly depend on planning variations and not weekly or seasonal variations in actual patient demand.\(^3\)

\(^3\)Anders Plantin, Senior doctor and logistics at Skaraborg Hospital, interview 2011-03-23
Chapter 3

RESEARCH METHODOLOGY

The research methods chapter describes the content of this study from a strategy and methodological view. The research questions are the base for this study and define the general content and the boundaries of the study. The methodology described in this chapter shall therefore define how the research progressed and how the research questions were answered in the study.

3.1 RESEARCH STRATEGY

This study has been followed through with the strategy described in Figure 3.1. The first phase in the strategy is a discussion of the contents of the study, i.e. the different parts, the scope and the limitations. This phase adds up to the background, problem area and research questions as described in chapters 1.1, 1.2 and 1.3. A literature study then follows with the background of the previous phase and with the aim of creating a base for future data collection. The data collection is done in a both quantitative and qualitative manner (literature study, interviews and observations) due to the character of the problem. With the literature study, hospital study and benchmarking done the analyzing phase of the study continues. Based on the analysis a framework is then created. The last phases of the study aim at validating the framework and delivering the results.

![Figure 3.1: The research strategy](image)

3.2 DATA COLLECTION

The data collection consists of both primary and secondary data. Primary data is drawn from the interviews, observations and statistics while the secondary data is mostly drawn from the literature study. The primary data can only be found by access to the same interviews, observations and databases while the secondary data can be found by looking at the references at the end of this report.
3.2.1 Literature study

According to Creswell (2009) the literature can serve both as a base for designing the proposal and for use as relationships among variables or as a lens for the inquiry during the research. Since this study was based on a problem faced at the hospital, the literature study has only been used to explain relationships among variables analyzed in the study. These explanations have functioned as a base for understanding what the interviews, observations and quantitative data collection should consist of. The literature study has been very necessary for creating a framework for data collection, but also for creating a framework for the actual framework designed in this study. This is because a part of the study is to introduce the concept of industrial production planning to the environment of the hospital where very little production planning takes place. Table 3.1 describes the keywords used during the literature study. Medline database was used a well in order to find any articles that come out of healthcare journals but resulted in zero found articles.

<table>
<thead>
<tr>
<th>Key word</th>
<th>Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production planning</td>
<td>Emerald library; Science direct</td>
</tr>
<tr>
<td>Capacity planning</td>
<td>Emerald library; Science direct</td>
</tr>
<tr>
<td>Forecasting</td>
<td>Emerald library; Science direct</td>
</tr>
<tr>
<td>Healthcare planning</td>
<td>Emerald library; Science direct</td>
</tr>
<tr>
<td>Healthcare</td>
<td>Emerald library; Science direct</td>
</tr>
<tr>
<td>Master production scheduling</td>
<td>Emerald library; Science direct</td>
</tr>
<tr>
<td>Production scheduling</td>
<td>Emerald library; Science direct</td>
</tr>
</tbody>
</table>

3.2.2 Interviews

Some of the obvious responsibilities of the interviewer in an interview are according to Ekholm and Fransson (1992): inform about the purpose of the interview, to motivate the interviewee to give the information that the interviewer is looking for; ask questions, follow up on answers, register relevant information and to systematize and analyze given information. The less obvious responsibilities might be to attain a relevant strategy even in times of stress and to understand the mood of the interviewee. The two parts often have different purposes for their participation. While the interviewer knows its purpose, the interviewee might give answers that protect his own position and not leave information that could result in negative consequences for him [Ekholm and Fransson, 1992].

Interviews in this study have all been made with a semi-structured approach. Neither the area of production planning in the hospital environment nor the area of production planning in general was previously very well known to the author of this thesis. It was therefore necessary to not make interviews with pre-made ideas of answers or directions of the interviews. Just as the literature study the interviews helped with the planning of the qualitative data collection.

Table 3.2 lists the different interviews conducted in this study.

<table>
<thead>
<tr>
<th>Title(s)</th>
<th>Company/Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section manager</td>
<td>Södra Alvsborgs Sjukhus</td>
</tr>
<tr>
<td>Secretary</td>
<td>Södra Alvsborgs Sjukhus</td>
</tr>
<tr>
<td>Statistician</td>
<td>Södra Alvsborgs Sjukhus</td>
</tr>
<tr>
<td>Logistician and senior doctor</td>
<td>Kåresjukhuset i Skövde</td>
</tr>
<tr>
<td>Master planner and factory manager</td>
<td>Adet AB</td>
</tr>
</tbody>
</table>

The interviews with hospital staff acts as a base for getting knowledge about the hospital environment in terms of activities, planning and future challenges. The interviews with the industry company instead acts as a base for setting the theory into a practical ground and also for understanding the planning structure of a well functioning company.
3.2.3 Observation

Observation is a large part of this study, since in this study, one framework of theory is to be applied to a setting where this framework is not present at all. An observation of the current working procedures and patient processes is therefore necessary for understanding the environment of where production planning is to take place. The quantitative data collection can therefore aside of interviews, documents and audio-visual materials involve observations. The advantages with observation is that the researcher has a first-hand experience with participants in the system, the researcher can record information as it occurs, unusual aspects can be noticed and topics can be explored that might be uncomfortable for participants to discuss. The negative aspects might be that the researcher can be seen as intrusive and that the researcher might have bad attending and observation skills [Creswell, 2009]. There are different options in terms of participating, from complete participant to complete observer. This study however only involves participating as a complete observer.

The observations of the nurses and one of the doctors during their everyday work was necessary for understanding the activities they take part in, what their responsibilities are, how time consuming activities are and how they plan them. It took place during one whole day at the reception, where several people where observed in order to see all activities and responsibilities.

3.2.4 Statistics collection

The data’s used for the hospital study of the Urology department are all quantitatively taken from different databases at the hospital. Statistics regarding patient visits has been drawn for one system (Elvis), statistics regarding surgery from one (Orbit), statistics regarding remittance from one (Cognos) and statistics regarding manpower from another (medinet). Some have been collected by the author (remittance and manpower) while other data has been given by the statistician. It’s obviously important that all data is correct and it can be assumed that this is true in this case since no data has been collected in any other means than looking at computer databases. The question is then whether databases are correct, and the answer is no to some extent. While researching, some data has changed from day to day even when data relates to information several months back. This is described briefly in the recommendations section, see 8.2. However, data have not played a major role in creating a framework, it has more been a part of understanding the current situation at the department and what types of information are needed to be able to successfully continue with a production planning process.

3.3 RELIABILITY AND VALIDITY

3.3.1 Reliability

According to Creswell (2009) qualitative reliability means that the researcher is using an approach that is consistent across different researchers and different projects. Yin (2003) also suggests that qualitative researchers need to document the procedures of their case studies and to document as many steps as possible of the procedures.

In all of the work relating to the hospital study and benchmarking, documentation has been an important part. From the literature study questions has consequently been added to documents relating to the hospital study and benchmarking in order to at all times connect the different parts with each other. The other way is also true, information gathered from the hospital study and benchmarking has led to increased literature studies. During observations and the several interviews a sheet of questions has always been present in order to cover the areas of interest, at the same time as these have been semi-structured to include information not thought of before. Observations were also very in-depth and gave information that was more than enough. Information has then instantly and consequently been typed down, and then compressed in a later phase for the final report.

3.3.2 Validity

Qualitative validity means that the researcher checks the accuracy of findings by employing certain procedure such member checking and to clarify bias. An important procedure might also be to spend prolonged time in the field and to use peer debriefing which would create in-depth understanding of the phenomenon and increase the accuracy [Creswell, 2009].

This has been done by both interviewing staff of the Urology department and observing them at work in order to understand what is important from both their perspective and the authors perspective. It has
also showed that the use of statistics has both strengthened and weakened statements from interviews and from the observation. Peer-debriefing has been used by asking staff (secretary mostly) to confirm information gathered. During the presentation of the thesis several people, which had not been involved before, also gave suggestions for improvements and better accuracy, mostly regarding the connection of staff between different activities. The literature studies have also been peer-debriefed with the supervisors of the thesis in order to include only the correct and necessary information.
Chapter 4

PRESENT SITUATION AT THE UROLOGY RECEPTION

The empirical setting of the report consists of two different parts: A study of the urology team at the hospital and a benchmarking of a manufacturing company from the industry. The hospital study was done by spending one whole day at the department, both with nurses, the secretary and the section manager. It’s also built up of regular communication with the secretary of the department, as well as historical data found in their database. The hospital study will be a base for understanding the processes of the department and what type of information is relevant or even necessary to have in order to manage the department in an efficient way.

4.1 UROLOGY TEAM

The urology team is part of the surgery clinic at SÄS, working with disease conditions relating to the urinary system of both men and women. The male sex organs are also included in the scope of the department. The most common conditions that the team handles are increased prostate size, urologic tumor conditions and different kinds of stone deceases. The most common referrals are incontinence and blood in the urine. The team is involved both with inpatient care and outpatient care. The inpatient care is located at a surgery department while the outpatient care is located at the team’s reception and the day surgery department.

4.1.1 Structure

The flow of patients can in general be described by Figure 4.1. The primary care in Sweden is normally supposed to be the first contact for the patient, unless it’s an acute illness. After a visit to the primary care, the doctor sends a referral to the specialist department (in this case the urology department). The referral is received by a secretary, prepared by a nurse and then evaluated by a doctor. If the referral is incomplete or not under the umbrella of the Urology department, it will be sent back to the primary care clinic. During high demand a patient can also be sent to a private clinic or a different hospital. Otherwise, the patient is scheduled for a first visit with a specialist. Before the first visit it’s also possible that the patient has been sent to other departments for tests that the doctor needs at the first visit. During the first visit, a doctor then examines the patient and decides if the patient is in need of any additional services, i.e. if there is a need for a re-visit or perhaps if the patient should be scheduled for surgery right away. A re-visit at this stage means that the doctor perhaps needs more tests results or just another examination. A re-visit can also lead to the release of the patient or a decision for surgery. In preparation for the surgery the patient is called back for a pre-surgery visit. During this visit the patient is informed by a nurse of the routines during the hours before and after the surgery, the patient is asked for information about his or hers status and finally a doctor examines and clears the patient for surgery. This pre-surgery visit is normally done a week before the surgery. The surgery then takes place at the surgery department with a doctor from the Urology team. The post care takes place at the ward where normally a doctor working at the reception has the responsibility to monitor the patients. Most patients that have had surgery then need regular controls, sometimes for many years, to make sure that the condition is progressing as hoped. As an example, patients with cancer in the bladder are scheduled to make re-visits until they have 10 years with no visible cancer. In the beginning, re-visits are made

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every third month, and after 2 to 3 years once every year. At this stage the patient is taken back to
the reception, either to a doctor, a nurse or a nursing assistant, depending on the condition and the
post-surgery status of the condition. If a re-visit shows that surgery is needed again the patient is just
forwarded in the same manner as before.

Figure 4.1: The general flow of patients belonging to the Urology department

There are ongoing process changes at the department though. For example, the pre-surgery visit is
now sometimes partly done at the re-visit with the patient. This means that the physician does not have
to participate in the pre-surgery visit because he or she has already signed the patient in for surgery.
The staff and their responsibilities are also best explained by a figure, see Figure 4.2. The Urology
team consists of four senior doctors, two doctors, three nurses and one nurse assistant. The senior
physicians work at the reception about one day a week, doing surgery about two days a week, the post-
surgery department and the pre-surgery planning combined usually one or two days a week and day
surgery about half a day every mouth. There is also scheduled time for administration and telephone
hours, which usually is included in the schedule with post-surgery responsibilities. The physicians work
at the reception only half a day every week, surgery two days a week and at the post-surgery department
about two days a week. One of the three nurses work only with reception and pre-surgery planning, while
one also work at the reception for prostate cancer control. The third one works almost entirely at the
reception for urotherapy. The nurse assistant works at the reception, the pre-surgery planning and with
the reception for urine flow control.

Figure 4.2: Staff at the Urology section and their responsibilities

Except the responsibilities of Figure 4.2, all senior doctors also have evening and night duty, a week
straight every fourth week in average, while regular doctors have evening and night duty only once or twice every week in average. An important note is also that since the senior physicians have frequent duty, one is normally on compensatory leave, which means that normally only three senior doctors share the responsibilities of the reception, surgery and post-surgery department each week.

Some of the doctors do surgery within all diagnoses while some have wanted to specialize and therefore tries to limit their width of surgery types. This has been done for the goal of increasing quality of the service, not in an attempt to make the planning easier. The quality is perceived to be increased as some surgery demands 20 to 30 repetitions per year to retain the competence, while some surgery take 5 to 6 hours to complete and need to be done often in order to retain the skill. However, this split between responsibilities started just this year.

Patients are not treated on a first-come, first-served basis. Instead, the patients are categorized as soon as the referral is received. There are today five types of priority in the system. The most urgent one, cancer in children, is not handled at this department and therefore forwarded directly. Suspicion of cancer in adults is the next most urgent status, which then makes it the most urgent one at this department. If a physician suspects a cancer diagnosis the patient will be offered to see a specialist within two weeks. Priority one, two and three then follows. The number suggests how many months the patients have to wait. However, recently even for priority three there has been a waiting time for only about 4 weeks. The long-term goal is to receive all patients within 30 days.

Scheduled visits are normally not re-scheduled in favor of a more prioritized patient. Every day within the next 5 working days there are open slots for patients with the highest priority to make sure that urgent patients can be received without disturbing the schedule.

In the everyday work at the reception, a patient is scheduled for a 20-minute visit. However, since no patient is like the other, it’s sometimes necessary to give the patient more time. Some patients even need 40 minutes, and the consequence of this is that the physicians have to work faster. It’s also possible that extra patients are received during the day, which creates the same situation. No patients are left behind though; the physician is done for the day when all patients have gone home.

4.1.2 Conditions today

The Urology department is among the top departments of the clinic and of the hospital in terms of queue times. They are now keeping the patient flow at a stable level and within the healthcare guarantee, but it’s the first time in many years. One of the reasons for this is that they recently had a period of working over hours to cut the queue.

The queue, defined as how many patients are waiting to be scheduled for an appointment, is in fact very low today. About a year ago the queue was reduced from about 50-60 down to between 0 and 10. The queue is not relevant in every circumstance though since it doesn’t show the real demand. It is more interesting to study the waiting times and the total queue of patients waiting for a visit or surgery. A patient with the highest priority can today get an appointment within a week, and the rest of the patients usually get an appointment within 4-6 weeks. The aim of the clinic is to receive all patients within 30 days, which is then not very far from the actual state of this reception. In total as of the end of February 2011 the waiting list for a visit consist of 120 patients. 86 (71.7%) of these have been on the list between 0 and 30 days, 33 (27.5%) have been on the list between 31 and 60 days and 1 (0.8%) has been on the list between 61-90 days. No patient in the list has so far waited longer than what the healthcare guarantee demands. The development during the last years of the amount of patients waiting for a visit can be seen in Figure 4.3.

1Christine Nyberg, senior doctor and section manager at the Urology department, interview 2011-02-04
2Christine Nyberg, senior doctor and section manager at the Urology department, interview 2011-02-04

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Figure 4.3: Amount of patients waiting for a visit at the Urology section.

It clearly shows that the amount has gone down during the last three years. Figure 4.3 also shows that during 2010 the total amount of patients waiting for a visit has been stabilized at a level between 70 to 130 patients. Figure 4.3 can be expanded into Figure 4.4 which shows in more detail how long the patients of 2010 have been waiting. More than 90% of the patients, except in January, have been waiting less than 30 days. The amount of patients outside of the healthcare guarantee is with only one exception down to zero patients.

Figure 4.4: Average waiting times (in days) for first visit patients during 2010.

Figure 4.5 also shows that the healthcare guarantee has been increasingly satisfied during the last years. As of most part of 2010 nearly all patients (first visit-patients) waited less than 90 days for their visit.

Figure 4.5: Amount of patients (%) that have waited less than 90 days for their first visit.

By only looking at the reception one does not get the whole picture though. It’s also necessary to study the amount of patients waiting for surgery. Figure 4.6 shows the development during the last three years.
years. It does not show the total amount of patients waiting for surgery, however, it’s concluded that this reflects the total development of surgery patients.

![Graph of Amount of patients waiting for surgery](image)

**Figure 4.6: Amount of patients waiting for surgery (3 diagnosis types)**

The development of how many patients that had to wait less than 90 days for a surgery is not as obvious as it is for those who were waiting for a visit. Figure 4.7 shows the development for 2007-2009 for 3 diagnosis types\(^3\) (Figures of 2010 were not available with the same diagnosis).

![Graph of Share of patients that waited less than 90 days to surgery](image)

**Figure 4.7: Share of patients that waited less that 90 days to surgery (3 diagnosis types)**

Three other diagnosis types\(^4\) can instead describe 2010. Figure 4.8 shows the outcome of 2010. The amount of patients waiting for surgery varies between 30 and 70 and clearly a lot more patients end up outside of the healthcare guarantee (>90 days).

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\(^3\)Hernia, non-descendent testicle and benign enlarged testicle.

\(^4\)Resection of prostate, hernia and benign enlarged testicle.
Figure 4.8: Average waiting times to surgery during 2010 (3 diagnosis types)

Looking at the demand at the department we can see that there are clear variations in incoming remittance during 2010. What these depend on is difficult to say since there can be variations of staff at the primary care clinics and private clinics just as there can be variations in the amount of patients asking for an examination. However, by the introduction of the healthcare guarantee the primary care clinic has to, by law, make sure that a waiting patient is taken care of within one week. The variations in remittance should therefore reflect the actual demand by the patients most of the time. Figure 4.9 shows the incoming remittance during 2010, excluding incomplete remittance. It also shows how many of the incoming remittance that are forwarded to other clinics, either due to limited capacity or due to an agreement with a clinic at a different hospital.

Figure 4.9: Demand counted as remittance during 2010.

4.1.3 Planning at the Urology section

The manager of the team/section, one of the senior doctors, does the planning today and is planned to do so in the future as well. It can be described as being divided into two parts. On a three-month perspective a planning is made that concerns planned holidays and weeks of watch. In this perspective, all doctors are aware of what weeks they will work and whether or not they are on watch each week. The detailed planning is then made on a monthly perspective, with a horizon of 2 months. This information was given by the senior doctor in early February; however, by the start of March the aggregated planning was set 14 weeks in advance. The holiday schedule was even set 25 weeks (~6 months) in advance. The detailed planning was at this time set 9 weeks in advance. One of the problems is that doctors sometimes asks for late changes which demands acute schedule changes, and in general the doctors have powerful wills when the schedule is set according to the senior doctor. At the moment there is no intention to change the planning routines.

The planning by the section manager only concerns the doctors though. The secretary does scheduling for the nurses on an aggregated level. The more detailed planning, as what to do each day, is done by the nurses themselves according to where they are needed by the doctors and how much of their own work they have to do.

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5Evening and night duty during a normal week of work. During watch they have to be available within two hours.

6Christen Nyberg, senior doctor and section manager at the Urology department, interview 2014-02-04.
None of the planners are presented with any historic data or forecasting regarding past and future demand in relation to the planning. However, they are presented with figures at least yearly about the status of the department. The only concern when planning is that they have an agreement that states that they are obliged to meet a certain number of patients with a certain capacity of staff.

The activities and the regular schedule of today is explained by Figure 4.10. The reception is only open on Monday through Thursday and the patients for pre-surgery planning are only received on Wednesdays and Thursdays. Doctors do all operations on Monday through Thursday. Due to this the post-surgery (ward) has to be manned every day. The other services, such as urine flow control and prostate cancer control, are handled by the nurses when there is time for it, outside of their duties of assisting the doctors. There are also irregular scheduled time for administration and supervising patients via the phone. Some days are also scheduled for further education or seminars.

<table>
<thead>
<tr>
<th>Area/Weekly</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reception</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-surgery planning</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Post-surgery</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Prostate cancer control</td>
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<td></td>
</tr>
<tr>
<td>Urine flow</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urotherapist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4.10**: Activity schedule at the Urology section

As for the planning of patients, the two secretaries do most of this job. They plan for reception appointments, urine flow control and occasionally also for the urotherapist. The planning for the prostate cancer control is done by the nurse herself. Another aspect of the patient planning is that patients with difficult illnesses have to be scheduled with the more experienced doctors. However, the majority of illnesses and patients can be treated by all of the doctors.

It is interesting to also look at the outcome of this planning. Figure 4.11 shows the planning of the reception, in terms of how many days every month the reception has been open. One open day means one whole day for one doctor at the reception meeting patients. Figure 4.11 also shows the total amount of patients during each month and how they are divided between first visits and re-visits. Re-visits are naturally more at this reception due to for example cancer patients that need regular check-ups.

**Figure 4.11**: Open days of reception compared to patient visits during 2010.

From Figure 4.11 it's then possible to calculate an average amount of patients per day of open reception, stated in Table 4.1 as efficiency.

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7 Marie Högfeldt, secretary at the Urology section, interview 2011-02-09
Table 4.1: Efficiency during reception of 2010.

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of visits</td>
<td>187</td>
<td>197</td>
<td>273</td>
<td>225</td>
<td>246</td>
<td>266</td>
<td>133</td>
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<td>213</td>
<td>241</td>
<td>245</td>
<td>239</td>
<td>2655</td>
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<tr>
<td>Reception</td>
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<tr>
<td>Efficiency</td>
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<td>15.2</td>
<td>16.1</td>
<td>13.4</td>
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</tbody>
</table>

It is argued that the planning of re-visit (after surgery) has been ruined by the health guarantee, since there is more incentive to treat patients within their first cycle at the department. And without the help of a private reception they would not be able to fulfill the healthcare guarantee\(^8\). According to the section manager there is no possibility to increase the capacity with the manpower of today at the reception since the amount of nurses and nurse assistants that know the procedures and the placement of tools are limited. There is a hope to increase the staff with one nurse though in order to increase their capacity. According to the secretary\(^9\) room capacity is not a major problem if the reception would increase the capacity one week, neither the staff capacity would be a major issue since in fact there is already today two receptions two afternoons every week. The issue would instead be that equipment might limit the possibility to examine more patients since some of the equipment needs to be washed in a machine in between patients.

The planning in relation to manpower for surgery and the outcome of this planning is shown in Figure 4.12.

![Manpower versus patients](image)

Figure 4.12: Scheduled surgery compared to amount of treated patients during 2010.

Table 4.2 shows the average amount of surgery (elective surgery) made in relation to how much doctors was planned for surgery, stated as efficiency.

Table 4.2: Efficiency during surgery of 2010

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of surgeries</td>
<td>48</td>
<td>44</td>
<td>56</td>
<td>50</td>
<td>46</td>
<td>48</td>
<td>26</td>
<td>34</td>
<td>54</td>
<td>41</td>
<td>35</td>
<td>49</td>
<td>531</td>
</tr>
<tr>
<td>Manpower at surgery</td>
<td>23</td>
<td>31</td>
<td>36</td>
<td>30</td>
<td>28.5</td>
<td>31</td>
<td>26</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td>24</td>
<td>32</td>
<td>348.5</td>
</tr>
<tr>
<td>Efficiency</td>
<td>2.1</td>
<td>1.4</td>
<td>1.6</td>
<td>1.7</td>
<td>1.6</td>
<td>1.5</td>
<td>1.0</td>
<td>1.2</td>
<td>1.9</td>
<td>1.4</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

The nurses have three receptions of their own, in varying responsibilities as stated before, and the variation of their demand described as how many patients they have appointed is shows in Figure 4.13.

---

\(^8\) Christer Nyberg, senior doctor and section manager at the Urology department, interview 2011-02-04  
\(^9\) Marie Höglöf, secretary at the Urology section, interview 2011-02-04
Figure 4.13: Appointments made by the nurses at their own receptions during 2010.

The average appointments per month during the years of 2007, 2009 and 2010 are 13.2 (urine flow), 79 (urotherapist) and 56.5 (prostate cancer control).

One critical part of the planning according to the section manager is that one rare diagnosis seldom comes alone, if a patient with a rare illness comes in this week, it can be expected that another patient with the same illness come in the week after. The detailed planning of when there is a need for a certain doctor or a certain service is therefore difficult to make.
Chapter 5

BENCHMARKING

The benchmarking presented in this chapter was done as an interview with the factory manager and the master planner of the company. Questions about their general planning setup and structure are meant to be answered in order to understand how a successful production company plans their activities to meet the demand. The scope of the benchmarking is the same as the scope presented before in Figure ??.

5.1 INDUSTRY PRODUCTION PLANNING

The benchmarked manufacturing company in this study is Atlet Products, which is a separate unit within Atlet AB. Atlet is a global company within material handling with a focus on warehouses and flow analysis, service, education and safety inspections. Atlet exist in 47 different countries with affiliates and distributors, where Atlet AB is the Swedish section. Atlet Products is a manufacturer of a wide range of electric forklift trucks, from small hand driven trucks to large 9.5 meter high capacity pickers.

Atlet Products are only focusing on assembly in their facility, which means that they buy all parts from suppliers and assemble them according to orders that they receive. This means that they are product and market oriented rather than production oriented. This also means that the production plan is not separate from the delivery plan. There is no inventory for finished products except the products that are due for delivery. The only inventory they have is for the parts that they get from their suppliers. The only exception to their assemble-to-order strategy is that it’s sometimes necessary to adjust a certain product due to a customer specification and this could mean extra welding, painting or assembly. Lately they have been implementing line and takt production in opposite to a functional assembly where few people in a limited area build the truck. At this time only one product is still built in a functional setting. This implementation is considered to increase the quality, efficiency and control.

The planning is as with most other organizations divided into different levels, with different horizons. The scope of this benchmark is the same as the scope of the thesis and therefore only includes the mid-term and short-term planning. However, in this case the long term and mid-term planning is basically the same thing. Atlet Products planning structure is presented in Figure 5.1. The master production scheduling is connected to the capacity planning, where the master production schedule creates a sequence for the assembly, down to what day a product shall be finished. The capacity planning makes sure that the master plan can be fulfilled in terms of material and manpower. The capacity planning mainly takes place here, but even in the short-term planning it’s necessary to make sure that capacity still can match the production plan. In the short-term planning the production scheduling takes place.
Figure 5.1: Atlet products planning structure.

The master production scheduling, capacity planning and production scheduling is described in more detail in Table 5.1. As the table shows the master production schedule and the capacity plan has a longer horizon than the production schedule. The freezing time is also half as short in the production schedule.

Table 5.1: Planning content for Atlet at long term/mid-term and short-term planning

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Bucket</th>
<th>Freezing time</th>
<th>Frequency</th>
<th>Input</th>
<th>Output</th>
<th>Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master production</td>
<td>5 quarters</td>
<td>Months</td>
<td>2 quarters</td>
<td>Every 3 months</td>
<td>Sales forecast</td>
<td>Capacity for quarter 5</td>
</tr>
<tr>
<td>Scheduling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>History</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Changes to quarter 3 and 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Working calendar</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Own judgment</td>
<td></td>
</tr>
<tr>
<td>Capacity planning</td>
<td>5 quarters</td>
<td>Months</td>
<td>2 quarters</td>
<td>Every 3 months</td>
<td>Sales forecast</td>
<td>Forecast of materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Delivery times</td>
<td>Information to suppliers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Material needs</td>
<td>Manpower needs</td>
</tr>
<tr>
<td>Production</td>
<td>2 quarters</td>
<td>Days</td>
<td>1 quarter</td>
<td>Every 6 weeks</td>
<td>Orders</td>
<td>Short term planning changes</td>
</tr>
<tr>
<td>scheduling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Capacity plans</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Forecast</td>
<td></td>
</tr>
</tbody>
</table>

The master production scheduling processes includes the master planner, factory manager, production manager, finance manager, sales manager and the CEO while the detailed planning process includes all of these except the CEO. The master production scheduling is a volume planning with a mid-term focus on models. The production scheduling is more of a mix planning focusing on products. When orders have
been received changes might have to be made to fulfill actual orders and usually around 5% of customer orders are changed and need to be adjusted for. The production scheduling is described as a planning process where questions like these are answered:

- How much do we have?
- How much should we have?
- What should we do?

Overall, the production system is quite flexible due to the fact that the production is open for an extra half hour every day except every other Friday when the production is usually closed. In case there is a high demand it’s possible to keep the production open even on that Friday and give the workers extra hours for vacation in a later period or higher salary. This creates a flexible environment where the capacity is adjusted to the demand with shorter notice.

The capacity planning on the long and mid-term level is a plan that uses sales forecast and production set times to calculate a need of manpower and equipment. The capacity of the production is though mostly limited by supplier capacity and therefore the capacity planning is even more important for calculating the material needs in order to prepare suppliers.

In each of these processes a follow-up is included in order to evaluate previous plans and outcomes.

The master production schedule works on the side of all this as the system that controls and support the decisions made in the planning phases and aids production staff in their daily operations.
Chapter 6

ANALYSIS

The analysis is based on the theoretical framework, the hospital study and the benchmarking. It's also grounded in the research questions, by analyzing around the different areas of scheduling, capacity planning and forecasting in order to give ideas of how the research questions can be answered. A general idea with the following results is that they should not be too advanced since acceptance is a major contribution to the successful implementation of a new system. At the same time, the result should not be too limited due to preferences of the staff. The analysis is therefore made with the mindset that the staff have the ability to learn about production planning and are able to change their routines.

6.1 ANALYTIC WORK PROCESS

The analytic work process is described in Figure 6.1. The beginning theoretical framework give the base for the data collection, where eafter empirical data is collected from hospital staff, the hospital data systems and the managers at the industry company. The analysis is done from theory and empirical data, and answers three of the four research questions. The fourth research question is answered by the creation of the production planning model.

![Diagram](image)

Figure 6.1: The analytic work process.

6.2 GENERAL ANALYSIS

A major reason for implementing a production planning process is the possibility to increasingly having a consumer driven workplace. A consumer driven workplace should be in favor of the patients, with shorter waiting lists and shorter throughput times from first visit to treatment. This can be done in this case by two basic procedures. The first is to look at an available forecast for the next periods, how the seasonality affects the demand and at what levels of average demand there is. The second basic procedure
should be to look at the latest present statistics regarding waiting lists to understand how demand has evolved up to the present period.

Another major reason for implementing a production planning process is the possibility to reduce variation in workload. By understanding the variations in demand and how the scheduling affects the demand it should be possible to even out the average workload for each day, week, month or period. This lies in the reason that when demand is temporarily not adjusted for, a higher workload will result in a later period.

The urology team can be described to work in an environment of make to order. It’s a flexible continuous line production since the tool, or the doctors approach, easily can be changed. Disregarding the competence input of the doctors it can be described as a high volume, high standardization type of production which normally is described as a repetitive mass production [Mattsson and Jonsson, 2003]. However, there is no make-to-stock resemblance since the production and the delivery takes place at the same time. The production planning can therefore depend on both manufacturing orders and an available capacity. This will be different for different types of visits. When regarding first time visits, the production planning will consist of an available capacity since this order queue is shorter than the planning horizon. For re-visit visits on the other hand, the production planning can consist of manufacturing orders since these are usually known well in advance. In order to facilitate this environment it’s still necessary to have a long horizon regarding the available capacity and the production scheduling. The production scheduling will make sure that a patient can be booked for a visit since a doctor’s schedule is set simultaneously with the scheduling. First visit patients are and will be booked as soon as possible in order to have a short through put time and to manage the healthcare guarantee. Re-visit patients can be booked with a longer perspective since they in most cases already have preliminary appointment day, months or even a year in advance.

Walley and Stein (2006) gives advice on what should be focused on to limit the impact of variation on system performance and especially these should be considered in the making of the planning processes:

- Really understand demand by forecasting.
- Maintain the right capacity plans to meet demand.
- Understand how the system introduces variation (i.e., by scheduling).
- Use process control measures to understand variation (i.e., use statistics).

Another point that Walley and Stein (2006) made was that there should be an expected date of discharge to make the processes more deterministic. Positively, this parameter is already in use.

From the the Institute for Health Care Improvement (IHI) a couple of points were found extra interesting relating to the planning:

- To anticipate demand with greater aim by knowing the statistics.
  - Necessary to keep statistics easily readable and present at all times.
- To even out variations, schedule control visits when more important visits have less demand.
  - Necessary to know the variations in demand.
- Adjust staff by predictable demands.
  - Adjust after knowledge, vacation is not allowed during peak periods. Use the forecast to plan for higher capacity when it’s needed.
- Reduce the queue.
  - Extra reception for a short period. Necessary to understand the short-term state of the department and the consequences of future planning.

To understand the demand and hopefully reduce queues there is a possibility in this case to, one, look at the forecast, and two, to look at the patient waiting list, as has been shown before in Figure 4.3 and 4.6. This number will tell the planner how many patients are waiting for a visit or surgery. By setting a capacity during the planning (the capacity need will be known when the planner has made a preliminary master plan) it’s possible to see if the available capacity will decrease or increase the waiting lists. By
comparing with the forecast as well the planner should get a good idea of the state of the department in the near future.

It also seems important to understand when and why patients should be sent to private clinics. Knowing the demand of the future by the forecast and by recent statistics gives the information to understand when this should be done and possibly how it can be limited. If the planner is aware that demand is going to be larger than usual for a near period the planner can take action within the department to facilitate this demand during a longer period. The other option would be to use overtime or sending patients to private clinics, which is costly.

Diagnosis codes or product families does not have to be treated in this thesis. It’s possibly not necessary for the reception to make this division right now. The small amount of work for dividing patients between doctors can be done internally and planned by the secretary. Therefore the planning unit will be the patient at both planning stages, not patients with specific kinds of needs. This could be changed in the future though if the doctors feel that it’s needed.

The process in which the planning resides can resemble the MRP II-system as shown in Figure 2.1. This process fits in the structure of the general industry and would most likely work as well in the hospital setting since there are no apparent structural differences that limit its use. At Sahlgrenska University Hospital they have a well-defined process that can be used in joint with the MRP II planning process since the first is somehow an emulation of the latter, with an emphasis on the hospital environment. A difference from today should most likely also be that the planning process includes more than just the department manager. The managing nurse and the secretary would be two good choices for staff to be included in the process. The secretary have knowledge about all patients and the current demand, while the nurse have knowledge about the nurses demand of patient (not related to the doctors) and also how the nurses can be able to fulfill the need of the doctors. The patients of the doctor seem to go first at all times, but there should be a discussion anyway in order to let the department manager understand the status of the whole department in a structured way. In the process of which the planning lies it’s also necessary to have the capacity perspective where it should reflect the structure of the master production scheduling and production scheduling.

Table 6.1 summarizes the general requirements of the planning system with basis from the theoretical framework, hospital study and benchmarking.

<table>
<thead>
<tr>
<th>Processes</th>
<th>Master production scheduling</th>
<th>Data</th>
<th>Amount of visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production scheduling</td>
<td>Amount of surgery</td>
<td>Waiting lists</td>
<td>Historical waiting times</td>
</tr>
<tr>
<td>Rough-cut capacity planning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity requirements planning</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Planningobject</th>
<th>Patients</th>
<th>Involve</th>
<th>Section manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planningunit</td>
<td>Visiting patients</td>
<td>Secretary</td>
<td>Managing nurse</td>
</tr>
<tr>
<td>Surgery patients</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input</th>
<th>Historic data</th>
<th>Output</th>
<th>Master production schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own judgment</td>
<td></td>
<td>Production schedule</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manpower/capacity schedule</td>
<td></td>
</tr>
</tbody>
</table>

Damping techniques are not really necessary in the planning tool since there is no present domino effect of planning changes outside of the freeze time. Within the freeze time patients possibly have to be rescheduled which is not optimum for the even flow of patients, but there will still be now domino effect.

One of the reasons for implementing the production planning was to shorten the queues. It’s of course necessary to give arguments why this is so. It has been discussed and well argued against (Eriksson et al., 2011) if it is beneficiary to have a waiting list. One reason would be that with a waiting list and somewhat longer waiting times some customers will decline to receive service because they perhaps not really need it. Another reason is that by having a waiting list it’s easier to use the resources more efficiently. Eriksson et al. (2011) argue against the misconception that waiting lists are good from a productivity point of view by stating that one of the several activities usually becomes a bottleneck. This would mean that this certain activity governs the total patient process output rate. According to the
clinic manager\(^3\) though this misconception is not used at this clinic. Minimum waiting lists are the goal for a production planning. This is the case because remittances are thoroughly analyzed when received in order to understand if there is a real need behind the remittance. A second reason is that doctors would really appreciate a schedule that is less full of patients every day.

To create a tool with these features it’s necessary and useful to use programs that are already in use at the hospital. It should be relatively easy for the staff to understand the program environment, and not have to spend time on getting familiar. It would also be beneficiary if the program could easily connect to the information database in order to automatically use information that has been previously added to the already existing database. A program that qualifies for these requirements is excel, with the visual basic for applications add on. Excel is an already used program by the secretary and most likely a familiar one for the section manager. It’s commonly known as a good tool for using statistics, creating diagrams and calculating advanced formulas. On top of this it’s also already used parallel to other statistic tools related to patient visits and treatments.

### 6.3 MASTER PRODUCTION SCHEDULING

The master planning is connected with the first of the two basic procedures for achieving a demand driven workplace. This involves looking at the forecast of the future, the average demand and deciding on the volume capacity within this horizon.

Even though this is a make-to-order environment it’s in some cases possible to plan with both manufacturing orders and an available capacity. The lead times for this department, or any hospital department, is though so short that the planning horizon is well past the lead times of any service. This and the fact that the waiting lists are so short mean that the planning can only depend on available capacity.

The purpose of the master production scheduling will be to fulfill the sales and operations plan, that more or less only state that the department should follow the healthcare guarantee. The master production schedule is therefore supposed to create a long-term production plan in order to meet demand by planning the capacity to where there is a demand. Compared to today it’s also supposed to create longer planning horizons in order to be more structured and not least for the secretary to be able to book patients well in advance and for the nurses to be able to plan their own work with a longer horizon. It will also be the basis for understanding any long term production changes and inquiries about vacations.

One important feature of the master production scheduling should also be that it should include a review of previous planning and the outcome of this planning.

Table 6.2 describes the requirements of the master production scheduling in order to meet the demand at this level.

<table>
<thead>
<tr>
<th>Input</th>
<th>Waiting lists</th>
<th>Periodlength</th>
<th>One month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Result of earlier planning</td>
<td>Freezetime</td>
<td>2 months</td>
<td></td>
</tr>
<tr>
<td>Recommended capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processfrequency</td>
<td>6-12 times a year</td>
<td>Output</td>
<td>Monthly production</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Monthly capacity</td>
</tr>
<tr>
<td>Planninghorizon</td>
<td>8 months</td>
<td></td>
<td>Forecasted effect</td>
</tr>
</tbody>
</table>

The master production scheduling should be fitted in a process in order to make sure that all features of the planning tool is used and that all inputs of the planning process is regarded. The planning process of the master production scheduling can be based on planned production orders, in this case the preliminary appointments for re-visits. It can also be based on planned production volumes based on the forecasts of the first visits and treatments. This is the case of this department. Other departments might have longer waiting lists and therefore have the possibility to base the planning on known preliminary appointments for re-visits and a long waiting list for first visits. The separation of these kinds of orders is necessary in order to reflect the present situation.

\(^3\)Lars Rex, clinic manager, e-mail conversation 2011-03-30
6.4 ROUGH-CUT CAPACITY PLANNING

The capacity planning can be derived from the make-to-stock environment since the overall demand isn’t very complex in terms of planning, with high volumes and high standardization. From a competence point of view each patient is a one-off production but in terms of planning there is no need to make the capacity planning more complex than this, at least not in the introduction of production planning. It is therefore suitable to use overall factors for capacity planning. It should not have to be more complex than this. Figure 2.4 shows the capacity planning with overall factors. As of today there is only one workforce for all of the patients during the planning, however, for the future it has been discussed to divide the patients. This division is still possible with the overall factors by increasing the amount of workforces. The nurses are a bit more complex to plan with respect to capacity. They will consist in the capacity planning on a different level, further down in the plan than the doctors. They have so many different responsibilities each day though that it’s not possible to plan their capacity in a relevant way.

Since the structure for production planning and control today is not well defined and supported it’s necessary to let the doctors have input on the capacity need for each patient. As seen before in Table 4.1 and 4.2 there is an average efficiency, but this should not be static because it might change with the introduction of production planning. The amount of patients appointed each day seemed to be thought of as larger than it actually was. Being able to set the efficiency during the planning might therefore highlight what the actual efficiency is.

Another view of the capacity perspective is that the change in volume capacity should resemble a chase-strategy since a volume change is very expensive. This is probably how it works in most hospitals today. If however there is a sudden increase in demand so that the demand is larger than the volume capacity it’s possible to buy the service from other clinics. With the volume capacity set, it’s still not necessary to use maximum capacity at all times, it’s not even possible due to regular compensatory leaves and vacations. Adjusted capacity is therefore necessary to reflect the variation in demand of visits and treatments and the variations in workforce. However, it’s not necessary that the compensatory leaves and vacations precede the planning. The adjusted capacity thinking could as well precede the decisions for compensatory leaves and vacations.

Table 6.3 shows the requirements of the rough-cut capacity planning in order to fulfill its purpose.

<table>
<thead>
<tr>
<th>Input</th>
<th>Efficiency</th>
<th>Output</th>
<th>Monthly capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity need</td>
<td>Manpower</td>
<td>Function</td>
<td>Comparing capacity need with available capacity</td>
</tr>
</tbody>
</table>

6.5 PRODUCTION SCHEDULING

The production scheduling is concerned with the second basic procedure of the production planning. It’s to look at the latest possible statistics regarding patients, in order understand recent demand and possible recent demand fluctuations. While it sets the planning on a daily basis it also acts as a control feature where it’s possible to understand if the master production schedule can work with satisfaction. The purpose is therefore to make a mix plan of the master production schedule. In the hospital setting it’s not possible to appoint a patient unless the production schedule is done, so without this plan there will be no production. This means that the production schedule also is based on production volumes, creating an available capacity, just as the master plan. The difference compared to the master production schedule is though that the master production schedule involves deciding on the daily mix between surgery and receptions.

The decisions that were made in the master production planning might not be possible to fulfill when it’s time to make the production schedule which means that the master planning phase has to be re-done in order to match the master production schedule and the production schedule.

The requirements of the production scheduling is described in Table 6.4.
Table 6.4: Requirements of the production scheduling

<table>
<thead>
<tr>
<th>Input</th>
<th>Master production schedule</th>
<th>Period length</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result of earlier planning</td>
<td></td>
<td>Freezemeter</td>
<td>2 months</td>
</tr>
<tr>
<td>Process frequency</td>
<td>12 times a year</td>
<td>Output</td>
<td>Daily production schedule</td>
</tr>
<tr>
<td>Planning horizon</td>
<td>3 months</td>
<td>Daily capacity schedule</td>
<td>Forecated effect</td>
</tr>
</tbody>
</table>

6.6 CAPACITY REQUIREMENTS PLANNING

The capacity requirements planning very much resembles the rough-cut capacity planning and doesn’t need a lot more of analyzing therefore. The requirements for this part of the planning can be copied from the rough-cut capacity planning except the period length. Just as the production scheduling, the capacity requirements planning is scheduled on a daily basis which gives a capacity output for each day of the planning month. Table 6.5 shows the requirements.

Table 6.5: Requirements of the capacity requirements planning

<table>
<thead>
<tr>
<th>Input</th>
<th>Efficiency</th>
<th>Output</th>
<th>Daily capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity need</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manpower</td>
<td>Function</td>
<td>Comparing capacity need with available capacity</td>
<td></td>
</tr>
</tbody>
</table>

6.7 FORECASTING

It’s easy to believe that forecasting is easy for a hospital since they basically produce the same service every year. This is not the case however. By the introduction of the health care guarantee many things have changed, including the patient flows. Due to the guarantee departments have been forced to cut queues and shorten waiting times. This is obviously very good for the patients since visits and possible treatments are made in a shorter time frame. However, this has made the statistics for the last years unpredictable and not always usable for a forecast. Figures previously shown shows that during the last couple of years, the waiting lists for both visits and surgery now stay at a relatively constant level, at least when comparing the last year with the three last years. It is therefore concluded that forecasts at this point only will be based on 2010 and after since before this there have been a lot of changes and special efforts to cut the waiting lists. The exception is though the remittance, which has should not have been affected from the same reason.

In the beginning of the study it was planned to use the forecast on first visits, re-visits, surgery and incoming remittance. However, values relating to visits and surgery are very much affected by the planning and doesn’t show the real demand unless you have a very good planning process that adapt the manpower constantly to changing demand. It’s therefore concluded that remittance should be the base for forecasting, because these values reflect the best view of the new demand at the moment. With the system of remittance processing today it’s not though very clear that the amount of remittance in the statistics show the real previous demand. Of all the incoming remittance (X), some are put away due to incorrect information, wrong address or where there is no need for a visit (Z). Some of the remittances are forwarded to private clinics and another urology department at a different hospital (Y). Figure 62 shows this process.

\[\text{Incoming demand is to be put on a waiting list}\]
Figure 6.2: Aggregated flow of incoming remittance

The problem with this has been that in the data system, remittance that goes to Skene department or the private clinic has not been separated. The remittance that goes to Skene department are usually very well motivated for, but the remittance that goes to private clinics only cost money to the urology department. So what the real need of the urology department is, is difficult to say. As of today the department is keeping track of this separation, but the data system still doesn’t unless someone actively search and divide every single remittance. Overall it can be concluded that demand is not far from the amount X in Figure 6.2 since remittance that goes to private clinics has not been many of the total amount.

The forecasting methods used for the analysis are moving average, exponential smoothing and regression analysis. Methods for trends and seasonality might also be important to consider. Table 6.6 shows the forecasting analysis that was made to understand what kind of methods are relevant.

<table>
<thead>
<tr>
<th>Method</th>
<th>Database</th>
<th>36 months</th>
<th>3 years (i.e., last three January’s)</th>
<th>Not relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving average</td>
<td></td>
<td>Can only forecast one month</td>
<td>Not relevant</td>
<td></td>
</tr>
<tr>
<td>Exponential smoothing</td>
<td></td>
<td>Can only forecast one month</td>
<td>Not relevant</td>
<td></td>
</tr>
<tr>
<td>Regression analysis</td>
<td></td>
<td>Possible</td>
<td>Not relevant</td>
<td></td>
</tr>
</tbody>
</table>

There is a possibility to make the forecast on either the last couple of months or a certain month for the last couple of years. This is not very accurate though because it would take at least a year for the forecast to adapt to a very different demand. For example, if there would be an increase in the demand for the next twelve months starting with January, the forecast would not see this increase before January a year after the increase. By using the data from the last months instead the forecast would notice the increase within just one month. Then, by using this strategy, it is no longer interesting to use the moving average or the exponential smoothing anymore because they can only forecast one period at a time by themselves.

It is then necessary to compare the different setups of regression analysis. The good thing about regression analysis, compared to moving average or exponential smoothing, is that it already includes the trend. It doesn’t include seasonality however which calls for a comparison. Figure 6.3 shows the comparison between regular regression analysis and regression analysis with seasonality.
This comparison was made with the basis of 2008 and 2009 and with a forecast of 2010 that was compared to the statistics of 2010. The standard errors of these two methods are 22.2 with seasonality and 25.7 without seasonality. Not very much difference in other words, but Figure 6.3 obviously show that with seasonality it’s possible to see the seasonal effect compared to the average, which is difficult to understand when not regarding the seasonality.

By measuring and forecasting the amount the remittance it could possibly be enough to understand the demand for first-visits. It is interesting to look at the relation between remittance and first visits. Looking at 2010 though the amount of remittance for a month compared to the amount of first visits the percentage varies between 36% and 67%. When comparing the remittance of one month and the first visits of the next month we get a percentage between 30% and 71%. With better planning according to demand and shorter patient waiting times these figures might be better, but at the moment it’s not possible to draw a relation between remittance and visits. The issue at this department is also that first visits are just a small part of the total amount of visits (36% in 2010). These can be described as surge demand, since they are harder to forecast. The re-visits on the other hand are not affected by the healthcare guarantee and are usually known well in advance which makes it possible to even them out during the year. These can be described as the base demand. For a different department, i.e. one without cancer patients that need regular checkups, the majority of visits might be first visits, which would call for a different planning perspective. Re-visits and treatments can therefore be forecasted by looking at a regression analysis of the last couple of years to get an idea of the trend and a reflection of the average amount. This should give a good base for understanding the need during the whole year and how the planning will affect waiting lists. It will only be an indication though and regular analysis of the current situation should be done in addition to looking at these forecasts.

By looking at the last 12 and 24 months the statistics can also give an extra view of the actual patient visit and surgery trend during the last two years, see Figure 6.4. However, this seems to be not very relevant now either because of recent cut in waiting lists. Due to recent overtime the statistics doesn’t show accurate demand from one year back and further. The forecasts of visits and treatments will therefore be based on the last twelve months, see Figure 6.5. This most likely gives a more updated and correct view of the nearest future.
Figure 6.4: Regression analysis of first visits, re-visits and treatment, with a base of two years.

Figure 6.5: Regression analysis of first visits, re-visits and treatment, with a base of one year.

Even though the forecast at the moment shouldn’t be based on more than one year it’s interesting to look at the average amount of visits and treatments during the last 12 and 24 months. This can give an idea of the trend during a longer period. Table 6.7 shows a summary of these values.

Table 6.7: Average amount of visits and treatments from April 2011 12 and 24 months back respectively.

<table>
<thead>
<tr>
<th></th>
<th>last 12 months</th>
<th>last 24 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>First visits</td>
<td>80</td>
<td>76</td>
</tr>
<tr>
<td>Re-visits</td>
<td>145</td>
<td>181</td>
</tr>
<tr>
<td>Elective treatment</td>
<td>39</td>
<td>44</td>
</tr>
</tbody>
</table>

This easily understandable and simple table can give a good understanding of the trend during the last 24 months. By dividing the amounts in 12 and 24 respectively it’s also possible to see the amount per month that have to be produced in order to, most likely, meet the demand.

6.8 EVALUATION

During the analysis and during the creation of the planning tool, the resulting tool was evaluated by several people, mostly from the industry point-of-view. They consist of people from the school with an industry background, people from the hospital with an industry background as well as a shorter background at the hospital, and one person from the industry that has been working at a hospital for several years. The evaluation gave ideas to further development and changes to the already existing features.

The goal at the start of the project was that the planning tool was to be tested and evaluated by the section manager, who is the one that’s suppose to use it, but due to the shortness of time this seemed to not be possible. There were two goals with this. One was to understand if the planning tool was clear and understandable for him and to see if something was missing from his point-of-view. The other goal was evaluate the outcome of a test planning, by using old information, from 2010, and make him use the planning tool based on this information to create a schedule for 2011. The results of the schedule could then have been compared with the actual schedule of 2011.
Chapter 7

RESULTS

7.1 PROCESSES

The general process of the production planning system is described in Figure 7.1. The processes included in the scope of this thesis creates two different plans as shown in Figure 7.1, a master production schedule and a production schedule. These are based both on the general planning on a sales- and operations level as well as the current condition at the department, i.e. waiting lists and manpower.

![Diagram](image)

Figure 7.1: The general process of production planning.

With the structure of Mattsson and Jonsson (2003) and the Sahlgrenska structure (fig 2.5) a master production scheduling process was created, shown in Figure 7.2.

![Diagram](image)

Figure 7.2: Master production scheduling process.
The first step involves adding historic values to the planning tool and analyzing these in terms of “what happened?” and “what did we expect to happen?”. The second step regards the forecast and known customer orders and creates a preliminary production plan based on the needs of the patients. The third step involves the capacity planning, where available capacity is analyzed in comparison with the capacity need based on the preliminary master production schedule. If the capacity plan covers the need of the master production schedule, then everything is set to make a decision out of this.

The planners basically only have to input their decisions in the production planning step and the capacity planning step. If these two are within limits of each other and fulfills the desire of the planners then there’s nothing more to do but accept it. Everything else is created automatically by the tool or by input of the secretary.

The process that the production scheduling is made of is described in Figure 7.3. Most of it resembles the master planning process except two features. There is no forecast anymore and if the capacity planning shows that the production plan is not possible to fulfill, then the planner either has to go back to the production scheduling or further back into the master production scheduling.

Figure 7.3: Production scheduling process.

During the master production scheduling and the production scheduling the follow-up can be described by three questions that are directly copied from the benchmarking,

1. What do we have?
2. What should we have had?
3. What shall we do?

By answering these questions the foundation for production planning has been set. They should, with their simpleness, start the minds of the planner to understand what the statistics can tell him, what they previously had planned for to happen and what they shall do in the future to continue with the goal of being a demand driven workplace.

7.2 THE PLANNING TOOL

In the creation of the planning tool, and analyzing behind it, all the statistics that are presented in the hospital study has been an important input into understanding what is important for the staff and the hospital in general to know. Both for understanding future planning and to be able to present production volumes for the decision makers in a retro-perspective. It therefore includes many of the figures that have been seen before.

The planning tool is a single excel file and consists of 8 worksheets:

1. History
2. Forecasting
3. Master production scheduling
4. Rough-cut capacity planning
5. Production scheduling
6. Capacity planning
7. Follow-up


The planning tool will now be shown in the order above, starting with the history. (The manual can be found in the appendix.)

The history worksheet consists of statistics regarding remittance, visits, treatments and manpower for visits and treatments respectively. Each column represent one month. The yellow fields highlight the fields that are to be filled in by the staff as each month go by, these figures are just statistics and not affected by any planning decisions. The only except to this is a field named queue for revisits which is shown as a horizontal yellow field. These are the preliminary appointments that have been planned sometimes up to a year in advance. To the right of the worksheet graphs are presented according to what information is asked for, by clicking on the yellow cells the graphs change. By clicking on the buttons “Roll backward” and “Roll forward”, the statistics move to the right or the left. Rolling forward is done when new statistics are to be inserted, by clearing the yellow fields of old information. See Figure 7.4.

![History Worksheet](image)

Figure 7.4: “History” worksheet.

The second worksheet, “Forecasting” consists of forecast for remittance, visits, treatments and nurse visits. It also consists of average values regarding the last 12 and 24 months. By clicking on the yellow cells the graph to the right will present history and forecast of each respective area. These values are also inserted into the master production scheduling and the production scheduling to be able to calculate the expected output after the plans have been made.
The third worksheet, “Master production scheduling”, consists of the actual planning phase, where monthly planning of reception, treatment, pre-planning visits, ward, telephone hours, administration and nurse receptions are planned, see Figure 7.6. The horizon is 8 months, where two (red cells) are locked, two (green cells) are due to be planned and the rest (yellow cells) are open to planning if there is a wish to plan far ahead. By inserting the amount of patients that should have a visit, the tool gives a suggestion for amount of receptions per month. The planner is then free to choose the exact amount of receptions that is wanted. This works the same for treatment. The expected output based on what the planner actually choose to plan is then shown in a graph, in terms of expected waiting lists. The waiting lists are based on the forecast from the previous worksheet and the production plan from this worksheet. Number 6 in the figure shows the previous output which acts as a follow-up where the old production plans can be compared to the actual output. All of the worksheets including this one moves one month forward as the “Roll forward” button is pressed in the “History” worksheet.

As the master production scheduling has prepared a preliminary production plan it’s necessary to evaluate this with the rough-cut capacity planning, Figure 7.7 shows the worksheet “Rough-cut capacity planning”. The capacity planning calculates the capacity need for each activity from the master production scheduling and summarizes this information into an aggregated need for every staff group. The planner inserts the amount of working days for every staff member and can then compare the total available capacity with the capacity need. The master production scheduling doesn’t involve any activities
outside of work related to the patients, which is necessary to understand when inserting the available capacity. The available capacity should only reflect capacity where staff is present to work with the activities in the planning tool.

<table>
<thead>
<tr>
<th>1 – Staff</th>
<th>2 – Working days of each respective staff member</th>
<th>3 – Staff need for each activity</th>
<th>4 – Summarized activity need per month of each staff group</th>
<th>5 – Summarized need in total per month for each staff group</th>
</tr>
</thead>
</table>

Figure 7.7: “Rough-cut capacity planning” worksheet.

The production scheduling is the next step in the planning process if the master production schedule has been accepted. Since this planning is made with an input from the master production schedule, number 1 in Figure 7.5 shows both the master production schedule and the total amount of activities that have been planned in the production schedule. Number 2 is where the planner adds activities per day, usually with the exceptions of weekends. The button “Update” summarizes the production schedule. The worksheet also shows the expected output of the production scheduling if it’s not possible to fill the schedule up to the amount of the master production schedule. It also shows previous plans and actual output for these plans in order to understand how the plans have been met and what possibly should be done during this planning to better meet demand or if it’s best to continue with the same strategy. This feature, which is also present in the master production schedule, is important for understanding what output a future plan might have.
Figure 7.8: “Production scheduling” worksheet.

The capacity planning at the production scheduling level resembles the rough-cut capacity planning very much. The only basic difference is that on this level the planning is done per day, just as in the production scheduling. The capacity need for each activity is taken directly from the rough-cut capacity planning and doesn’t need to be stated once again. The daily capacity need is then transferred from the production scheduling and on this sheet the target is to plan the available capacity per day in order to meet the capacity need. By looking vertically (between 2 and 3) in Figure 7.9 it’s possible to compare the daily capacity need and availability. By looking horizontally on the other hand (between 1 and 2) it’s possible to compare the available capacity that was planned during the master production scheduling with the aggregated available capacity from all days of the present month. The button “Update” summarizes the daily capacity into an aggregated monthly capacity.

Figure 7.9: “Capacity planning” worksheet.

The “Follow-up”-sheet should not only be used as a follow-up even though it might seem like it. An important part of creating a demand driven workplace is that all staff are aware of the future planning and can relate to this. Many of the nurses for example, that aid the doctors in their daily work but also runs their own receptions will have great value in knowing in advance what they are planned for and when they have time to receive patients of their own. At the same time this acts as a part of information sharing about output of previous work. The graphs shown below in Figure 7.10 highlights the important
measures for understanding how goals and targets have been met in the past.

1 – Amount of first visits and waiting list, 2 – Waiting times for first visits, 3 – Re-visits and waiting list, 4 – Amount of receptions, 5 – Waiting times for elective treatment, 6 – Amount of nurse visits, 7 – Master production schedule, 8 – Production schedule.

Figure 7.10: “Follow-up” worksheet.
Chapter 8

DISCUSSION,
RECOMMENDATIONS AND
FURTHER RESEARCH

8.1 DISCUSSION

The planning tool and the processes behind it described in the previous chapter are suggestions of a tool and of processes that can be used if the decision is to introduce production planning at the Urology section. It's at the moment adapted to their needs and requirements, and involves information and planning functions in order to plan for first visits, re-visits and treatments. The tool and the processes are made to relatively easy be used by the secretary, managing nurse and section manager. The processes should not be difficult at all to understand, the tool on the other hand demands training. It needs training to understand all features of the planning tool, how the forecasts work and how the planning actually introduces changes into the everyday work. It might also take time before it reaches its fullest potential and creates an everyday demand driven workplace. At this point the section should be able to have a top-view of the current situation, where results are understood from previous planning and where the decision makers understand that one decision affects many different things.

During this study it has been understood that product families are slowly being introduced both by administrative staff and doctors, though not very much so far. This has led to the thought if this should be included in the planning tool. So far this has not been used enough at the section in order to introduce into the planning or not. It feels a little bit early to introduce both production planning and product families at the same time. However, introduction of product families is relatively easy and is a natural next step after introducing the production planning processes and tools. The separation of patients between doctors is so small today that it's done by the secretary and advised to continue so.

Another area for development is the capacity planning. Capacity plans are with the current design based on overall factors with a daily perspective, mostly for the doctors' work and just slightly for the nurses so far. This can be developed into considering hourly capacity needs and plan for both doctors, the nurses' work relating to the doctors and the nurses work that they have by themselves.

The planning processes and planning tool is not necessarily used only for the sections own purposes. There would probably be good benefits from creating planned discussions between different section managers with this tool as a base. By looking at the waiting lists and forecast of the different sections that use the same resources, i.e. the surgery department, it's possible to understand who is in most need of the resource. For example, if one department is far behind on the surgery waiting list and one has a very good status, then one can plan less surgery for one week in favor for the other one. The released capacity at the reception that is not needed can then be transferred to help the other with increased amount of receipt visits. This would create an even more demand driven work place/hospital. This could be described as cross-sectional planning in other words.

A shortcoming of the tool that should instantly be fixed if possible is that it's not connected to the data system at the moment. All of the information/statistics that are required for the tool to be useful are available in one or another way but not automatically inserted in the planning tool. As of today the secretary, with help from administration will have to manually enter figures into the tool. In a future version of the tool this should be done automatically in order to limit the necessary work amount and to
increase the accuracy.

The actual demand of the urology department is not as easy to understand as one could wish. First of all, it’s not possible to say how well the primary care is at forwarding the remittances that they write after meeting the patients. Routine changes at the primary care can change the noticeable demand at the urology department. However, due to the healthcare, late forwarding should be limited nowadays. The other reason is that some remittances are sent to another hospital for different reasons. Some of these are relevantly forwarded, while some might be due to limited capacity at the Urology department. Some remittance are also sent to private clinics. This should be limited because it cost money and there is no medical reason for forwarding remittance here. The problem is that it’s difficult to say from the past how many has been sent to private clinics and to the other hospital (and how many of these that have been relevant). In order to understand the demand this should definitely be well understood, which it will by the introduction of the planning tool.

8.2 RECOMMENDATIONS

The question of introducing the planning tool and the planning processes might seem simple, but are not as simple as they seem. It was stated in the beginning that the resulting work of this study has to be understandable in terms of content and how it shall be used, because if it’s not accepted it won’t work. It therefore takes time to make this work. The following is a list of things to consider when implementing and maintaining the production tool.

• Introduce the planning tool and the concept of production planning processes to the secretary, the managing nurse and section manager. Possibly more than once with a follow-up after the introduction in order to make sure they have started. Make sure that everything is clear about who does what and when. This step is also important for understanding what changes have to be made to the tool to make it more fitting to this section.

• Think of the first time as a test period. It will take at least a couple of months before it’s possible to understand the full potential of the tool since it’s necessary to see how the planning actually develops into results.

• Keep regular follow-ups with the secretary, managing nurse and section manager. Both because they might need further instruction, but perhaps even more importantly because it’s necessary to keep developing the tool and the processes. If they are not using the tool as much as expected it might be because they don’t find it useful or that it has flaws. A lot can be understood by just looking at how they use it without asking them how they use it as well.

• Key process indicators are used in the production tool but can be developed further by using more data (increase accuracy), as well as creating new indicators by storing more statistics that are related to the planning. Some interesting indicators are visits per remittance, treatment per remittance and visits per nurse reception.

• The planning tool comprises of visual basic programming and needs regular management during any change of the production tool. A small change in the design of the excel file can make it unusable unless the visual basic code is maintained.

A couple of things need to be considered as well in order to develop and create an environment around the planning tool and processes that is effective.

• The data used in this study has sometimes been changed from one minute to the other due to unknown reasons, even though the data has been several months old. This has been experienced by other logistician as well¹. These errors should be reduced by clarifying how data is inserted into the system and how different data are related to other data. The data should also be available in a way that is useful for the planning. i.e. it’s not possible to follow one patient from remittance to release. Instead, the data consists of independent figures of each step.

• Make sure that everyone has the same idea concerning what the data stands for.

¹Anders Plantin, Senior doctor and logistician at Skaranborg Hospital, Interview 2011-03-23
• Teach the secretary to find all of the information needed for the "History" worksheet. The less people involved in the operational part of the tool, the better, statistics will have better accuracy. Most of the statistics are present for the secretary today, but she will have to learn where to find them.

• In general, to be able to introduce a production plan to any department it's most likely useful to direct most energy to operative managers or any people that are directly involved in the use of the plan. When aiming at a higher level it's possible that the changes are not introduced as planned and that the purpose is not forwarded correctly.

• The planning for each section which the tool is implemented at should be synchronized with the planning of other sections. This way they can aid each other in meeting the demand.

8.3 FUTURE RESEARCH

At the start of this study it was planned to introduce the planning tool to the planners and to simulate a couple of months planning. This didn't work due to time constraints. A further research can therefore be to introduce the planning tool and even record actual planning and the results from this, and not just simulate it. This can give information regarding the possible gains with production planning. One gain would be that waiting lists become shorter both for visits and treatments. Another gain would be that the waiting lists have less fluctuation which would indicate that the planning has been made according to the demand and that staff can work in a less fluctuated environment.

Further research could also involve a broader perspective, with the surgery planning and ward planning. These have clear relations with the planning of the reception but need their own planning.
Chapter 9

CONCLUSIONS

It is relatively easy to implement production planning on a mid-term and short-term level at the Urology department. This master’s thesis show a practical example which can be used to introduce and start with production planning.

The research strategy during this thesis work has been to find theoretical information to create a framework for data collection and for understanding production processes. The theoretical framework also show that standard processes should be well functional within the hospital environment. With this framework a hospital study was made to understand the important areas to include in the results of the production planning processes and tool. The hospital study showed that information regarding previous patient activities, average waiting times of patients, waiting lists and manpower are important to know when trying to understand the past and the present. In order to plan for the future it showed that information regarding previous planning outcome, patient and remittance forecast, and expected outcome of future plans is important to have at hand.

During the hospital study and the analysis it was understood that in order to create a useful forecast it’s necessary to look at the incoming remittance. Forecasting of remittance alone is the only indicator of the new incoming demand, any other indicator such as first visits are affected by previous planning that was not made according to demand and is therefore not useful. A regression analysis with seasonal factors seems to give an adequate forecast of the nearest future. Visits and treatments are best forecasted by making a regression analysis without seasonal adjustments.

A benchmarking was made where a practical example of production processes was shown. The general thinking of these process added to the structure of the Urology processes, especially in the production scheduling where questions of “how much do we have?”, “how much should we have?” and “what should we do?” have been used in the resulting tool of this thesis.

The theoretical framework, the hospital study and the benchmarking all added important ideas and structures to the resulting tool. The tool is an easy to handle excel file which can be used monthly or less at the master production scheduling but at least monthly at the production scheduling level. By following the production processes created in this thesis and by using the production tool a good start has been made to implement and start to think in terms of production planning.
Bibliography


Appendix A

Detailed description of the Visual Basic for Applications-code

The VBA-code in the developers part of excel is divided among different windows depending on what the code is used for. The start-up code is positioned as one part, all of the procedures are positioned as one large part and for every worksheet there can be related code. The code on each worksheet basically only calls the procedures when a worksheet is active and used.

A.1 Start-up code

The start-up code is positioned in the Workbook folder:

Private Sub Workbook_Open()
UserForm1.Show

Sheets("Redovisning").Select
Range("A1").Select
Sheets("Kapacitetsplanering").Select
Range("G67").Select
Sheets("Detaljplanering").Select
Range("G65").Select
Sheets("Grov kapacitetsplanering").Select
Range("AP6").Select
Sheets("Huvudplanering").Select
Range("AP4").Select
Sheets("Prognos").Select
Range("B57").Select
Sheets("Historik").Select
Range("BH6").Select

End Sub

A.2 Worksheet codes

Three of the worksheets call procedures when the user actively click on any cell in the worksheet.

History
Private Sub Worksheet_SelectionChange(ByVal Target As Excel.Range)
    Call UpdateChart
End Sub

Forecast
Private Sub Worksheet_SelectionChange(ByVal Target As Excel.Range)
    Call UpdateChartForecast
End Sub

Master production scheduling
Private Sub Worksheet_SelectionChange(ByVal Target As Excel.Range)
    Call UpdateChartRuvudplan
End Sub

### A.3 Module code

The module code includes the procedures that are called either by buttons in the worksheets or by automatic calls from other procedures.
'Created by Tobias Peterson
'University of Borås
'Spring 2011

Sub ChangeMonthMasterForward()
'Change the month to the next month in the schedule

'Unprotect the sheets to be able to edit them
Worksheets("Huvudplanering").Unprotect
Worksheets("Grov kapacitetsplanering").Unprotect
Worksheets("Historik").Unprotect
Worksheets("Prognos").Unprotect

'Move the Master Production Schedule (expected outcome)-worksheet
For i = 3 To 39
    For u = 25 To 28
        Worksheets("Huvudplanering").Cells(u, i).Value = Worksheets("Huvudplanering").Cells(u, i + 1).Value
    Next u
Next i

'Move the History-worksheet
For i = 3 To 75
    For u = 25 To 66
        Worksheets("Historik").Cells(u, i).Value = Worksheets("Historik").Cells(u, i + 1).Value
    Next u
Next i

'Move the Master Production Schedule-worksheet
For i = 3 To 51
    For u = 4 To 22
        Select Case u
            Case 4, 6, 7, 9, 10, 12, 13, 15 To 22
                Worksheets("Huvudplanering").Cells(u, i).Value = Worksheets("Huvudplanering").Cells(u, i + 1).Value
        End Select
    Next u
Next i
Move the Rough cut capacity planning-worksheet
For i = 3 To 31
    For u = 6 To 19
        Select Case u
            Case 6 To 11, 13, 14, 15, 17, 19
            Worksheets("Grov kapacitetplanering").Cells(u, i).Value = \
            Worksheets("Grov kapacitetplanering").Cells(u, i - 1).Value
        End Select
    Next u
Next i

Add a new date at the end of the history-worksheet
Depending on the month and what year, days are added so that each month starts at the 1st.
Select Case Month(Worksheets("Historik").Range("B33"))
    Case 1, 3, 5, 7, 8, 10, 12
        Worksheets("Historik").Range("B33").Value = Worksheets("Historik").Range("B33").Value + 1
    Case 2
        Select Case Year(Worksheets("Historik").Range("B33"))
            Case 2012, 2016, 2020
                Worksheets("Historik").Range("B33").Value = Worksheets("Historik").Range("B33").Value + 28
            Case Else
                Worksheets("Historik").Range("B33").Value = Worksheets("Historik").Range("B33").Value + 28
        End Select
    Case 4, 6, 9, 11
        Worksheets("Historik").Range("B33").Value = Worksheets("Historik").Range("B33").Value + 30
End Select

Worksheets("Historik").Range("B335").Value = 0

Protect the worksheet again
Worksheets("Historik").Protect
Worksheets("Huvudplanering").Protect
Worksheets("Grovh kapacitetplanering").Protect
Worksheets("Fordon").Protect

Call the procedure to move the production planning
ChangeMonthDetailedForward

End Sub
Sub ChangeMonthMasterBackward()
    'Change the month to the previous month in the schedule

    'Unprotect the worksheets
    Worksheets("Huvudplanering").Unprotect
    Worksheets("Grov kapacitetsplanering").Unprotect
    Worksheets("Historik").Unprotect

    'Move history backwards
    For i = 1 To 66
        For u = 3 To 66
            Worksheets("Historik").Cells(u, 76 - i).Value = Worksheets("Historik").Cells(u, (76 - i) - 1).Value
        Next u
    Next i

    'Move expected output backward
    For i = 1 To 32
        For u = 25 To 26
            Worksheets("Huvudplanering").Cells(u, 40 - i).Value = 
            Worksheets("Huvudplanering").Cells(u, (40 - i) - 1).Value
        Next u
    Next i

    'Move master production schedule backward
    For i = 1 To 66
        For u = 4 To 22
            Select Case u
                Case 4, 6, 7, 9, 10, 12, 13, 15 To 22
                    Worksheets("Huvudplanering").Cells(u, 52 - i).Value = 
                    Worksheets("Huvudplanering").Cells(u, (52 - i) - 1).Value
            End Select
        Next u
    Next i

    'Move the rough-cut capacity planning backwards
    For i = 31 To 1 Step -1
        For u = 6 To 19
            Select Case u
                Case 6 To 11, 13, 14, 15, 17, 19
                    Worksheets("Grov kapacitetsplanering").Cells(u, i).Value = 
                    Worksheets("Grov kapacitetsplanering").Cells(u, i - 1).Value
            End Select
        Next u
    Next i

    'Protect the worksheet again
    Worksheets("Historik").Protect
    Worksheets("Huvudplanering").Protect
    Worksheets("Grov kapacitetsplanering").Protect

    'Call the procedure to move the production schedule backwards
    ChangeMonthDetailedBackward

End Sub

Two more procedures exist for moving the production scheduling and the capacity planning forward and backward. These are though very much alike the procedures above for the master production scheduling and the rough-cut capacity planning. They will therefore be left out here.
Sub UpdateDetailplan()
'Update the production schedule worksheet to calculate the sum of all of the days

Worksheets("Detailplanening").Unprotect

'Find out how long the month is in order to sum only the days of the actual month
Select Case Month(Worksheets("Historik").Range("B3"))
    Case 1, 3, 5, 7, 8, 10, 12
        Forward = 31
    Case 2
        Select Case Year(Worksheets("Historik").Range("B3"))
            Case 2012, 2016, 2020
                Forward = 29
            Case Else
                Forward = 28
        End Select
    Case 4, 6, 9, 11
        Forward = 30
End Select

'Sum it up
For i = 1 To 14
    Sum = 0
    For u = 185 To (185 + Forward - 1)
        Sum = Sum + Worksheets("Detailplanening").Cells(i, u)
    Next u
    'Show the sum
    Worksheets("Detailplanening").Cells(i, 2) = Sum
Next i

Worksheets("Detailplanening").Protect
End Sub

The capacity planning worksheet has the same procedure as above for that specific button as seen before in the results chapter.

Sub ColorDetailplan()
'Color the production schedule worksheet depending on what day it is (weekdays=green, weekends=orange)
Worksheets("Detailplanening").Unprotect

Select Case Month(Worksheets("Historik").Range("B3"))
    Case 1, 3, 5, 7, 8, 10, 12
        Forward = 31
    Case 2
        Select Case Year(Worksheets("Historik").Range("B3"))
            Case 2012, 2016, 2020
                Forward = 29
            Case Else
                Forward = 28
        End Select
    Case 4, 6, 9, 11
        Forward = 30
End Select

'Start by coloring everything blue
For i = 1 To 246
    For u = 1 To 14
        Worksheets("Detailplanening").Cells(u, i).Interior.ColorIndex = 37
        Worksheets("Detailplanening").Cells(u, i).Interior.Pattern = xlSolid
        Worksheets("Detailplanening").Cells(u, i).Interior.PatternColorIndex = xlAutomatic
    Next u
Next i
For i = 185 To (185 + Forward - 1)
    For u = 5 To 14
        Select Case Weekday(Worksheets("Detailplanering").Cells(u, i)).Value
            Case 1 To 6
                Worksheets("Detailplanering").Cells(u, i).Interior.Color = 4
                Worksheets("Detailplanering").Cells(u, i).Interior.Pattern = xlGray25
                Worksheets("Detailplanering").Cells(u, i).Interior.PatternColorIndex = xlAutomatic
            Case 7
                Worksheets("Detailplanering").Cells(u, i).Interior.Color = 44
                Worksheets("Detailplanering").Cells(u, i).Interior.Pattern = xlGray25
                Worksheets("Detailplanering").Cells(u, i).Interior.PatternColorIndex = xlAutomatic
        End Select
    Next u
Next i
Worksheets("Detailplanering").Protect
End Sub

The code below updates the charts on the "Master production scheduling"-worksheet depending on what the user want to show (by clicking on certain rows or columns). A similar code is written for the "History"-worksheet and the "Forecast"-worksheet but are very extensive and not really necessary to show even here.

Sub UpdateChartMuvudplan()
    'Re-draw the charts on the Master production schedule-worksheet depending on where one clicks
    Worksheets("Muvudplanering").Unprotect
    Dim ChtObj As ChartObject
    Dim UserRow As Long
    UserColumn = ActiveCell.Column

    'Every case represents a certain column
    Select Case UserColumn
    Case 54
        'Hide the charts that are not used right now
        ActiveSheet.ChartObjects(3).Visible = False
        ActiveSheet.ChartObjects(4).Visible = False
        ActiveSheet.ChartObjects(5).Visible = False

        'Set the title, content and label for all curves of the chart
        Set ChtObj = ActiveSheet.ChartObject(2)
        ChtObj.Chart.ChartTitle.Text = "Plan vs unfall - Muvud";
        ChtObj.Chart.SeriesCollection(1).Name = "=";"Muvudplanering\R25C8\R25C9"
        ChtObj.Chart.SeriesCollection(1).Name = "=";"Vantek, plan"
        ChtObj.Chart.SeriesCollection(2).Values = "=";"Muvudplanering\R25C8\R25C9"
        ChtObj.Chart.SeriesCollection(2).Name = "=";"Vantek, unfall"

        'Show the chart that is asked for
        ChtObj.Visible = True
    End Select
End Sub
Case 57

ActiveSheet.ChartObjects(2).Visible = False
ActiveSheet.ChartObjects(4).Visible = False
ActiveSheet.ChartObjects(5).Visible = False

Set ChObj = ActiveSheet.ChartObjects(3)
ChObj.Chart.ChartTitle.Text = "Plan vs utfall - Återbävak"
ChObj.Chart.SeriesCollection(1).Name = """"Väntelista, plan"

ChObj.Chart.SeriesCollection(2).Values = "=Huvudplanering!R34C3:R34C39"
ChObj.Chart.SeriesCollection(2).Name = """"Väntelista, utfall"

ChObj.Visible = True

Case 60

ActiveSheet.ChartObjects(2).Visible = False
ActiveSheet.ChartObjects(3).Visible = False
ActiveSheet.ChartObjects(5).Visible = False

Set ChObj = ActiveSheet.ChartObjects(4)
ChObj.Chart.ChartTitle.Text = "Plan vs utfall - Operation"
ChObj.Chart.SeriesCollection(1).Name = """"Väntelista, plan"

ChObj.Chart.SeriesCollection(2).Name = """"Väntelista, utfall"

ChObj.Visible = True

Case 65

ActiveSheet.ChartObjects(2).Visible = False
ActiveSheet.ChartObjects(3).Visible = False
ActiveSheet.ChartObjects(4).Visible = False

Set ChObj = ActiveSheet.ChartObjects(4)
ChObj.Chart.ChartTitle.Text = "Plan vs utfall - SMA"
ChObj.Chart.SeriesCollection(1).Name = """"Väntelista, plan"

ChObj.Chart.SeriesCollection(2).Name = """"Väntelista, utfall"

ChObj.Visible = True

End Select

Worksheets("Huvudplanering").Protect

End Sub

VIII
Appendix B

The “Manual”-worksheet

The last of the eight worksheets is shown in figure B.1. It consists of a short description about all of the other worksheets, including the possibilities to change the present month of planning and changing the graphs in some of the folders.

![Manual worksheet]

Figure B.1: The manual worksheet