

**Improve and Secure the Supplier Capacity Process
Within IKEA's Plastic Category in Greater China**

Thesis by

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**In Partial Fulfillment of the Requirements
for the Degree of
Master of Science in Mechanical Engineering**



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Preface

This master thesis has been written during the spring of 2012 and is the final part of our Master of Science degree in Mechanical Engineering at Lund University, Faculty of Engineering.

During this period we had the opportunity to meet and experience a lot different cultures and professional people within the IKEA organization. The thesis has been carried out at the IKEA Trading office in Shenzhen China and at IKEA of Sweden office in Älmhult in collaboration with the Production Management institution at Lund University, Faculty of Engineering.

First of all we would like to thank our supervisor Paul Björnsson at IKEA for his support and passionate commitment during the project. The responsible within the category plastic; Mattias Adamsson and Minh Nguyen Hoang have also been a good and appreciated support during our project time. We also want to acknowledgement our supervisor from the Lund University Peter Berling for his much appreciated help and guidance during the project. At last we also would like to extend our gratitude to all the people involved within the plastic category at the trading office in Shenzhen, China for giving their fullest support when implementing this process at the suppliers in China and Taiwan.

Lund, 2012

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Abstract

- Title:** Improve and Secure the Supplier Capacity Process within IKEA's Plastic Category in Greater China
- Authors:** Carl-Fredrik Lie and Toste Elinder
- Supervisors:** Paul Björnsson – Process Leader for Plan & Secure Capacity, IKEA of Sweden
Peter Berling – Department of Production Management at Lund University, Faculty of Engineering
- Purpose:** The purpose of this thesis is to implement the One Supplier Capacity Process, a standardized method of working with capacities within IKEA. In order to do this the current way of working with capacities is investigated prior to the actual implementation of the process. The key contribution of the authors is the development of a template to support the implementation process and ensure accurate capacity figures and support the capacity planning process. After the implementation the One Supplier Capacity Process is evaluated with regards to its key components, its implementation, and the results and potential to improve the capacity planning process for IKEA and its suppliers.
- Methodology:** As the authors were actively involved in the implementation phase by adapting the One Supplier Capacity process to the specifics of plastic production, the chosen methodology was participatory action research with a normative approach. The study is deductive and mainly qualitative based on interviews and observations of IKEA employees and suppliers.
- Conclusions:** The One Supplier Capacity Process provides a much needed framework for working with capacities that is lacking today. With the support of the template it provides a standardized method of calculating the capacities to ensure their accuracy, and allows allocation of production resources shared between products. It gives IKEA an insight into the suppliers' productions that enable proactive work with regards to operationally maintaining availability. The insight should also enable IKEA to more efficiently secure tactical dedication of capacity at its suppliers.

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List of Abbreviations

BD	Business Developer
BDM	Business Development Manager
CRP	Capacity Requirement Planning
GPS	Global Purchasing System
HFB	Home Furnish Business
IM	Injection Machine
IoS	IKEA of Sweden
MRP	Material Requirement Planning
MPS	Material Planning System
OSCP	One Supplier Capacity Process
PG	Product Group
RG	Resource Group
RM	Raw Material
SM	Support Machine
SPI	Supply Plan Information
SP	Supply Planner
TA	Trading Area
TOC	Theory of Constraints
UR	Unique Resource

1 Introduction

The intention of the introduction is to provide an understanding of the reasons behind this master thesis. This includes a background of the problem they experienced by IKEA. This is then developed into a purpose and constrained by the company directives as well as the authors' delimitations. The target group is presented along with an overview of the company and the key processes and functions connected to this thesis.

1.1 Background

In all large companies the planning is vital to stay successful among all other strong competitors in the global market. Capacity planning is one important part of a company's planning. Capacity planning for IKEA is how to determine the production resources within the suppliers. Capacity is a measure of how much of a product that can be produced by the manufacturer in a given time period. There are extra costs related to having a capacity that is too high or too low. A good capacity planning will minimize the secured capacity to insure low cost while retaining a good availability of the product by meeting the demand.¹

The capacities could be defined in different ways and it is of great importance that the company has a clear understanding on how the suppliers have calculated their capacities. When having a number of suppliers defining and calculating the capacities in dissimilar ways the use of these figures will deteriorate significantly.

In 2010 a report was published showing the "Top 100 worsties" of IKEA overall performance. This report presented that 44% of these problems was due to supplier capacity issues.² When this was presented, it was realized that a solution needed to be developed to reduce these problems. The One Supplier Capacity Process (OSCP) is a process being implemented with the objective to standardize the methods of working with capacities in order to insure accuracy in the capacity figures maintained and provide a standard framework to make the capacity planning process more efficient³.

1.2 Problem Discussion⁴

IKEA currently has difficulty in determining the capacity of different suppliers within their categories which has led to availability problems. One reason is because there is no standardized method of evaluating and securing capacity. Although there is a general framework for working with supplier

¹ Mattson & Jonsson, 2005

² Björnsson, (2012-01-23)

³ Ibid

⁴ Ibid

capacities it is not followed locally, meaning there is no specific decision-making framework or procedure to follow when capacities cannot be met. The decisions being made locally means that figures are updated infrequently and irregularly.

Capacity is determined on single article level or groups specific to certain suppliers. It means that there are difficulties translating capacity between different articles from different suppliers and also for articles that share similar production resources. The key factors for determining the capacity of a production facility are the critical resources, or bottlenecks, in production. One thing OSCP aims to do is to provide a framework where the capacity is derived from the capacity of the bottleneck and easily translated between product groups bound by this bottleneck.

Another issue is that the capacity is registered in different units of measurement such as volumes, purchasing value, pieces of end products, and square meters. The reason is that although there is a framework in place ensuring the decision should be made by the category globally, the measurement of capacity is essentially decided locally. The solution OSCP will provide for this problem is to focus on one measure for IKEA that is globally defined and this measure is to be pieces of end products. The simple logic used to justify this choice is that all goods are essentially sold in pieces.

These fundamental problems with the method of planning capacity as well as frequent deviations of the registered and demonstrated capacities has led to an overall lack of trust in the capacity figures inserted in the internal planning system.

1.3 Purpose

The purpose of this master thesis is to investigate IKEA's new OSCP model of determining the capacity of their suppliers. It is summarized into the following four points:

Map and analyze how IKEA and its suppliers are working today ("as-is") with supplier capacity planning.

The first task is to investigate IKEA's current method of determining the capacity of their suppliers and how they work with them. This will provide an understanding of the perceived capacity and a basis for investigating the impact of an eventual change using OSCP.

Implement ("to-be") the common way of working with One Supplier Capacity Process

The next step is the implementation of the OSCP process IKEA has developed. The focus for the implementation is the development of a template to effectively apply the process to the plastic productions visited and address any complications that can arise in a standardized manner.

Evaluate the One Supplier Capacity Process

The new process is compared to the current system used to determine whether any benefits have been realized. The capacities determined using the process are evaluated, but the main focus with regards to savings are qualitative benefits in the suppliers' and IKEA's capacity planning processes. The implementation process is also evaluated and compared to relevant theory.

Contribute to improve the One Supplier Capacity Process

Throughout the implementation and analysis of OSCP any potential improvements in the implementation and maintaining of the process should be identified. This includes both from the suppliers' and IKEA's point of views.

1.4 Directives

IKEA has approximately 1,000 suppliers in 53 countries⁵, and investigating all of them is an unrealistic feat given the time constraints for the thesis. The following directives have been assigned by the company in order to restrict the scope of the thesis.

Product category

The authors have been tasked with focusing specifically on the product category Plastics. IKEA has already determined that product groups should not contain articles from different segments. This delimitation will therefore still allow the investigation of different article groupings in different segments within a category.⁶

Geography

China has been chosen as a starting point for the rollout of IKEA's new capacity planning process and subsequently the investigation will only affect Chinese suppliers. Suppliers are largely grouped with regards to which category of products they produce, and Plastics are produced around the city of Shenzhen in the Guangdong province. Here there are 7 suppliers, and in addition there are 2 suppliers in Taiwan meaning a total of 9 suppliers will be investigated.⁷

1.5 Delimitations

The total time spent on the project is 20 weeks; 12 weeks of this time will be spent in China. This will limit the depth of the project both with regards to the investigation of the suppliers as well as the analysis of the results, where quantitative savings with regards to the calculated capacities resulting from the process are difficult to analyze. When calculating the capacity for each supplier the total capacity except

⁵ Andrukiewicz (2012-01-27)

⁶ Björnsson (2012-01-23)

⁷ Ibid

for capacity dedicated to other customers is regarded. The basis for the capacity allocation will be the current need decided on supplier level.

1.6 Target Groups

This thesis report is mainly written for employees at IKEA to give guidance on how to proceed to implement the OSCP process as well as an evaluation of its potential benefits. It could also be used by other students who want to immerse themselves in capacity planning. It is therefore assumed that the reader has basic knowledge of production management.

1.7 Company Descriptions

1.7.1 General description

Ingvar Kamprad founded IKEA in 1943 in a small village called Agunnaryd in Sweden. Today it is one of the world leading companies in the furniture business, with 131 000 coworkers in 41 countries and with an annual revenue of over 24,7 billion euro. About 88 percent of all IKEA stores are fully owned by IKEA and the remaining stores are operated by other franchisees owned outside the IKEA Group.⁸

The company is divided into three groups; the IKEA Group, Inter IKEA Group and the IKANO Group. The IKEA Group encompasses all from warehouses, distribution, and also owns the stores in each country. Inter IKEA Group owns the trademark and process and takes a franchise fee from all IKEA stores revenue, and the IKANO Group is an organization that deals with all financial work.⁹

IKEA's business idea is "To create a better everyday life for the many people". Their mission is to "offer a wide range of well-designed, functional home furnishing products at prices so low that as many as possible will be able to afford them."¹⁰

Kamprad has been keen on creating an ownership structure and organization that stands for individuality and sustainability. Therefore, the IKEA group is owned since 1982 by a foundation.¹¹

IKEA has adopted a process-oriented organization only recently in order to tie functions together to improve efficiency. The three main processes are Creating the Home Furnishing Business, Communicating and Selling, and Supplying. Within Supplying there are four core processes, one of which is Plan & Secure Logistics. To this process there is a sub-process called Plan & Secure Capacity (PSC) responsible for carrying out the capacity planning.¹²

⁸ IKEA (a)

⁹ IKEA (c)

¹⁰ IKEA (b)

¹¹ IKEA (c)

¹² IKEA Intranet (a)

1.7.2 Functions

There are three key functions within IKEA that are connected to the OSCP process:

Home Furnishing Businesses

IKEA of Sweden (IoS) is responsible for the development of the range of home furnishing products. This range is divided into eight Business Areas (BA), for example “Living Room and Workspaces” and “Lighting”, and complemented by a Free Range. This division is further disaggregated into 20 Home Furnishing Businesses (HFB), for example “Living room seating”, “Store and organize furniture” and “Workspaces” with the BA “Living Room and Workspaces”. At IoS there are Demand and Need Planners responsible for forecasting the need and aligning it to the capacity respectively.¹³

Categories¹⁴

In addition to belonging to an HFB each IKEA product also belongs to a category. The categories are based on products belonging to the same industry, meaning they share similar materials and/or production techniques, and as a result share a similar supplier base. The reason for this division is to coordinate the purchasing within the different industries rather than allowing the HFBs to separately perform this task.

Each category is led by one Category Leader at IoS and one or more at Trading Operations, who are accountable for the development of their category.

Trading Operations¹⁵

This is the unit within the Supply function responsible for supporting and developing the suppliers. The Trading Operations are divided into 9 regional Trading Areas (TAs). In each area the function is divided into Category specific teams. These teams consist of the following positions connected to specific key goals:

- Business Developer (BD) and Business Developer Manager (BDM)
 - Responsible for price development and ensuring environment and social requirements are met.
- Supply Planner (SP)
 - Responsible for ensuring product availability. This includes maintenance of the operational capacity figures.
- Technician
 - Responsible for ensuring product quality.

¹³ IKEA Intranet (c)

¹⁴ IKEA Intranet (a)

¹⁵ IKEA Intranet (d)

1.8 Time Plan

The key element in this thesis is the visiting of suppliers in order to determine their current methods of working with capacities as well as implementing the new OSCAP process. A more thorough investigation is performed for the two largest suppliers in order to provide a basis for an understanding of plastic production and how to implement the process. The consequent suppliers are visited once each, with two supplier visits per week as shown in the figure below.

WEEK	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220
LOCATION	SHENZHEN, CHINA											
ACTIVITY												
Supplier Visit and OSCAP Implementation												
Supplier 20383	SV & workshop		template sent	SV	analyze							
Supplier 19720	SV & workshop		template sent	SV	analyze							
Supplier 22195					template sent	SV	analyze					
Supplier 22358					template sent	SV	analyze					
Supplier 17389						template sent	SV	analyze				
Supplier 22310						template sent	SV	analyze				
Supplier 21293							template sent	SV	analyze			
Supplier 16039								template sent	SV	analyze		
Supplier 16642								template sent	SV	analyze		
Create and tweak capacity calculation template												

Figure 1. Time plan for the empirical investigation in Shenzhen in China.

2 Methodology

This chapter describes the different methods and approaches used when performing research. The used methods and approaches for this master thesis are also stated and motivated.

2.1 Participatory Action Research

Participatory action research (PAR) is a method of research used when the researcher is actively participating not only in the development phase of a project but also the implementation, while at the same time performing research about it. When doing this type of study the investigator is both a researcher and a manager, constantly implementing changes throughout the project based on ongoing analysis. When using this method the process will be updated during the course of the project. The development process in a project is normally very complicated and the PAR research method gives a better view of the reality through a close daily interaction. This also leads the potential to put the findings of a research into practical use quickly.¹⁶

Method chosen

The PAR method has been used during this project since the authors have been actively involved in the implementation of the OSCP process. The template used as a key tool to implement the process effectively was created by the authors and has continuously been updated following each new obstacle investigated and addressed.

2.2 Methodology Approach

The methodology describes the decided approach on how the study will be performed. There are four different levels on which the study could be formed; explorative, descriptive, explanative, and normative. This is based on the amount of existing knowledge in the specific research area. An explorative study is performed when there is little expertise within the area and the goal of the study is to reach a basic understanding. When there already is basic knowledge and understanding within the area and where the objective is to describe but not explain the relations the descriptive study method is used. Explanative research is used when you want to explain and describe a area deeper to get a better understanding, while normative study is used when knowledge already exist and the goal for the study is to dig deeper into the subject and locate ways to improve.¹⁷

Method chosen

A lot of research already exists within the field of capacity planning. As the thesis aims to implement a new process and evaluate and improve it based on existing theory the approach can be seen as normative.

¹⁶ Ottosson, 2003

¹⁷ Björklund & Paulsson, 2008

2.3 Induction, Deduction, and Abduction

There are normally two different methods to precede a research project; induction or deduction. The induction method starts with making the empirical study of the area without looking into the theory and instead the theory is based on the empirical study. The deduction method starts with the theory, and a funded theoretical hypothesis is tested empirically. When using both induction and deduction back and forth the method is called abduction.¹⁸

Method chosen

The deduction method is used for this master thesis, as the basic knowledge from the theory along with the OSCP process is the foundation for the research. The process is implemented through the template and empirically tested and evaluated.

2.4 Quantitative and Qualitative studies

A quantitative study contains information that could be measured or be validated numerically. This means that the results from these studies could be generalized to make conclusions. Qualitative studies are used to do deeper analyzes and the possibility to generalize is normally low.¹⁹

Method chosen

The calculations of the capacities is quantitative, but the main focus is the implementation and adaptation of the OSCP concept to the productions visited and evaluate the effect of the process as a tool to aid in capacity planning. It can therefore be concluded that the study is mainly qualitative.

2.5 Data Collection

The data being gathering to the research could be divided into two types; primary and secondary data. The primary data is data collected to be used specifically for the research work; for example interviews, questionnaires and observations. Secondary data is general public information; for example literature and articles.²⁰

2.5.1 Interviews

Interviews are categorized as a form of primary data and could be performed in various ways; for example by telephone, email, and face-to-face contact. The interviews could be structured, semi structured and unstructured. A structured interview uses predetermined questions in a specific order and is normally used when having a large number of interviews. Otherwise, if the question areas are decided before but the actual questions are decided at the interview and are formulated during the interview depending on

¹⁸ Björklund & Paulsson, 2008

¹⁹ Ibid

²⁰ Ibid

the interviewers' reactions the interview is called semi-structured interview. The last way is the unstructured interview where the questions are decided during the dialog.²¹

2.5.2 Observations

Observations can be done in various ways. One way of doing it is to be part of the activity and another way could be to observe the activity from the outside. The observation could also be varied by giving information in advance for more detailed information or by being performed in secret so the observed do not know that you are observing them, which will give a better picture of the reality.²²

2.5.3 Literature study²³

This is written material such as books, and articles. This is a secondary data because it isn't specific for the research, and this is important to consider when using information from this kind of source. The purpose of the material could be different from the research, which can render it unusable.

Method chosen for data collection

The interviews were performed both with the TA team in Shenzhen and with the suppliers during the project period. There were two different approaches used for trading and supplier respectively. The TA team was interviewed with a semi structured method face-to-face and the suppliers were interviewed by email in a structured form. The main reasons for this is because that the best way of doing an interview is to have it face-to-face to get more details and background to the answers. The good cooperation between the researcher and the TA team made it easy to ask questions as soon as they came up. The interviews with the suppliers were done by mail because of the distance to them and the limited time during the supplier visits.

The observations that have been done during the master thesis project have mainly been at the supplier visits. The observations have been done together with the suppliers through discussions and by factory visits.

The authors have based the report mainly on literature concerning capacity, process implementations, and other relevant theories to form the theoretical framework. The literatures have mainly been journals available from e-sources and written literature. In addition to this internal documents from IKEA have been used.

²¹ Björklund & Paulsson, 2008

²² Ibid

²³ Ibid

2.6 Credibility

In a scientific report it is important to show a high credibility to give the reader a necessary trustworthiness of the writer. To get this high trustworthiness in the report the research need to have good validity, reliability, and objectivity.

2.6.1 Reliability

The reliability is measured by repeating the study to make sure the same result is repeated whenever. If a study has good reliability it should be able to be repeated by other researchers in the same conditions and arrive at the same results. Without any repetition of the experiment and study the result will always have a low testability, meaning that the hypotheses are neither supported nor disproved.²⁴

2.6.2 Validity

The validity shows to what extent what was measured actually got measured. To get a high validity it is important to test with different perspectives. It is important to make sure the study is not angled towards a specific approach.²⁵

Below in Figure 2 the relationship between validity and reliability is depicted. The first dartboard shows that the results are consistent and therefore reliable, but the results are not correct. In the second dartboard the average of the results are centered showing slight validity but the spread means that there is low reliability. In the third dartboard the results are not centered on a specific value or the correct value, which means it has low reliability and validity. In the last dartboard the consistency is high and centered insuring high reliability and validity.

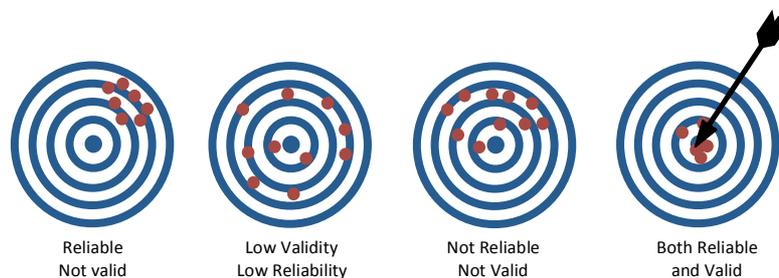


Figure 2. The different dartboards illustrate the relationship between reliability and validity.²⁶

²⁴ Björklund & Paulsson, 2008

²⁵ Ibid

²⁶ Based on Trochim, W 2006

2.6.3 Objectivity

The objectivity shows to what extent someone's evaluation has an influence on the studies. High objective could be archived if the researcher clarifies and explains the methods chosen, which will make the reader be able to take its own position in each manner.²⁷

Credibility of this thesis

This study is mainly based on supplier visits and interviews with the TA team in Shenzhen and suppliers of plastic products. The reliability of this study therefore depends on the repetition of each case that has been encountered. During the research period nine suppliers have been visited all with similarities to each other and a lot of dissimilarities. The complications discovered in one visit are repeatedly found during the other visits. This makes the reliability rather high but the visits are only performed in China and Taiwan, which means the situation may look different in other countries.

The validity of the information gathering from the supplier visits could be assumed to be pretty high by the reason of the number of visits and also the dissimilarity in production setups. The information gathered and the conclusions drawn have a high probability of being useful for other plastic suppliers. However again the investigation into only Chinese and Taiwanese suppliers may limit the validity with regards to applying to more automated or well planned productions in other countries.

The interviews were structured in one way for the suppliers and one for the TA team. The supplier's interviews were done in a structured manner with the identical questions to each that was sent by mail and answered by mail. The reasons for having just email interviews with the suppliers were because the supplier visits already gave answers to most of the questions and the interviews gave confirmations to these answers as well as some answers to additional questions. The interviews with trading were done in a semi-structured method with written questions and follow up questions to make sure the answers is reliable.

The research has a low objectivity mainly due to the authors' participation in the implementation process and specific application of OSCP to the plastic suppliers visited. The research has greatly been affected by these participants' ideas and thoughts that all together have shaped the research work.

2.7 Criticism of Sources

The sources that have been used during the supplier visits have been managers from the suppliers and trading from the office in Shenzhen. The suppliers visits has been done in generally two days which means it is a limited time for deep understanding. This means that there could be misunderstandings mainly because of the translations between English and Chinese, but also because of the sometimes low

²⁷ Björklund & Paulsson, 2008

level of knowledge from the suppliers. These errors have decreased by repeatedly asking follow up questions to make sure the answer is correct. By sending out interviews by email to the suppliers the data gathered during the visits could be confirmed. The close cooperation between the suppliers and trading also made it easy to make follow up questions on things that was found unclear after the visits.

Besides these possible causes of errors, there is also risk that the data they gave is wrong for things such as the cycle times for the machines and labor. This was secured at all suppliers' visits with a short production visit where some of these data was checked and the flows were controlled compared to the data collection sheet filled in by the suppliers. This is an important step in a supplier visit that makes the data collected more valid.

The TA at the IKEA office in Shenzhen on the other hand could also be a cause of errors in the project. Frequent meetings are arranged to make sure the project is going in the right direction. The interviews performed at the TA office have been with four different employees of varying positions to make sure the information is correct. The close cooperation in daily work between the authors and TA employees made it easy to discuss questions that came up and other issues.

2.8 Method of Implementing the One Supplier Capacity Process

The first step of the implementation of the OSCP process was an introductory workshop week planned by the project group from IoS with the aim of providing the local TA teams with a good understanding of the process. The agenda for the week was as follows:

- **Monday:** A presentation of the process was made by the project group from IoS followed by workshop with the Category teams in Trading from Shenzhen, India, and Taiwan.
- **Tuesday and Wednesday:** The week also included presentations and workshops at the two key suppliers in Shenzhen, A and B, that together stand for the majority of the total turnover within the Plastic Category in China. The workshop included investigation of a production line in order to perform Resource groupings and calculate consumption rates in order to familiarize both the suppliers and local Trading team with the process.
- **Thursday and Friday:** A final workshop was performed with the Trading teams and the IoS project group. The goal was to resolve any issues and questions raised to ensure a good understanding from all parties involved.

With the resulting feedback and experience from this introduction week a preliminary template was developed by the project team and expanded by the authors in order to effectively provide the suppliers with an efficient method of collecting the relevant data and processing it. Following the principles of Participatory Action Research this template was evaluated and improved as needed following each supplier visit in order to improve the implementation at each succeeding supplier.

The method of implementation developed at this point was to send out the latest version of the complete template to each supplier a few days in advance of the visit. They were asked to perform the data collection part of the template and to attempt to familiarize themselves with the data analysis part. After that the authors and the respective responsible Supply Planner or Business Developer visited the suppliers for a one to three day workshop at each supplier, depending on the complexity of and amount of products produced. This included a revisit to the suppliers visited in the introduction week.

3 Frame of Reference

In this chapter the theory that the analysis is based on is presented. Although the focus is capacity planning there is also a presentation on relevant theory pertaining to the Theory of Constraints management philosophy, machine grouping in productions, as well as supplier relationships and process implementation in order provide a basis for evaluating the implementation of the process.

3.1 Production Capacity

3.1.1 Definition²⁸

Production capacity is a measurement of level of output a production can generate in a given time period with the current resources. Common measurements include man-hours, machine hours, units, kilograms, or value (currency) per time unit. Regardless of the choice it is important that it reflects the aims of the organization, and that there is consistency in which measurement is used.

There are different levels of capacity as depicted in Figure 3.

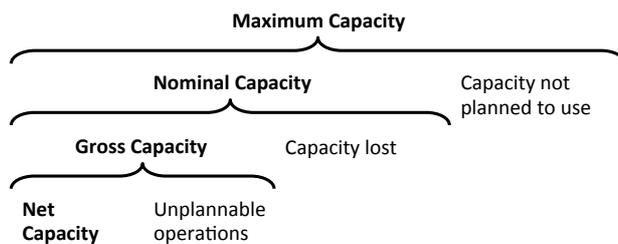


Figure 3. Illustration of different capacity levels.²⁹

Maximum capacity is the capacity given full operation every hour of every day in a year. This capacity is seldom utilized and therefore not of interest. Instead the nominal capacity is often calculated. This is the planned capacity with regards to four key variables: amount of machines or other production units in a production line, number of shifts per day, number of hours per shift, and number of working days per period of planning.

It is however again seldom the case that this even level is achieved. This is due to capacity lost as a result of for example machine breakdowns, labor absences, maintenance, and so on. When this is taken into account the gross capacity is determined. In order to arrive at the net capacity there are further unplannable events or operations that need to be taken into regard. These may include time spent on

²⁸ Mattson & Johnsson, 2005

²⁹ Based on Mattson & Johnsson, 2005

reviews with management, waiting time for materials, and so on. It also includes unplannable production dedicated to for example rework of claims and rush orders. The resulting net capacity is the true available capacity that can be utilized for production.

3.1.2 Capacity Planning

Capacity planning deals with ensuring that the capacity of production resources can meet the changing demands for products.

3.1.2.1 Levels of capacity planning

There are three different levels of capacity planning within production generally classified depending on the time frame. Strategic planning is long-term and focuses on expansion of capacity through capital investments. Mid-term tactical planning deals with the aggregate planning process of assigning resources to products. It involves time-staged planning to meet the demand, and includes decisions that modify the capacity such as labor hiring or firing and building stocks. In the short term operational planning the detailed decisions to execute the production are made. It involves planning and purchasing materials and scheduling the capacity and final assembly.³⁰

3.1.2.2 Tools for capacity planning

The key components to a successful planning process are the master production schedule (MPS) for the tactical planning, and the material requirements plan (MRP) and input and output (I/O) control for the operational planning (shown in Figure 4 along with the planning level to which the components belong). The MPS is a weekly plan that translates sales and operations planning into a production plan for specific time periods. This production plan is supported by MRP that ensures resource availability. The I/O control ensures the most efficient use of production resources. There are different types of capacity planning that differ in sophistication and hence support different levels of the production planning process. The differences in level of sophistication of these planning methods also influence their applicability to different production types.³¹

³⁰ Mattson & Johnsson, 2005

³¹ Tenhiälä, 2011

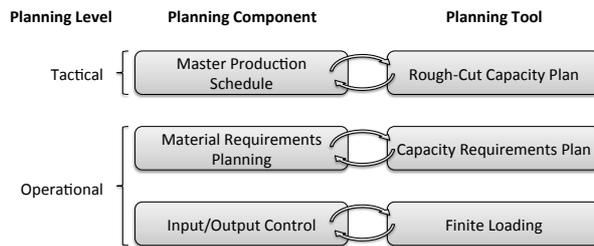


Figure 4. Relationships between planning levels, components, and tools. ³²

Non-systematic capacity planning

The simplest form of capacity planning is using a non-standardized approach. The MPS is based on experience to determine the feasibility. The Bill of Materials (BOM), a list of raw material and component requirements for an end product, supports the MRP and processing lead times are determined by averages and buffered by arbitrary safety lead times. The scheduling for the I/O control is based on priority rules for capacity leveling. ³³

Rough-cut capacity planning (RCCP)³⁴

RCCP is the simplest standardized capacity planning and is associated with the development of the MPS. This form of capacity planning aims to estimate capacity requirements on resource or resource group level, and is usually only used for resources that may have insufficient capacity and not for those with a history of low utilization. It does not take into account things such as subassemblies, setups, and batch sizes. There are three key approaches to rough-cut capacity planning, providing figures with accuracy relative to the detail of the input.

RCCP is an efficient planning tool to use in jobbing productions (Figure 5). This is because the high level of variation and low volume means that maintaining detailed information on specific jobs is difficult. Because the productions focus on general-purpose machinery there is a low level of complexity, which also suits RCCP.

³² Based on Tenhiälä, 2011

³³ Tenhiälä, 2011

³⁴ Swamidass, 2000

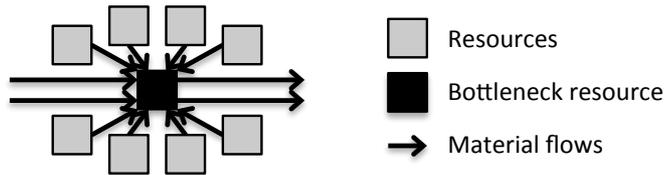


Figure 5. Jobbing production.³⁵

RCCP by method of overall factors

This first method requires information about the total standard machine or labor hours required by each finished product as well as a historical percentage about which operation these hours pertain to. As there is no account for lead time in this method it only provides good estimates of capacity needs when the production mix remains fairly constant.

RCCP using the bill of labor

The Bill of Labor (BOL) is a list of the capacity requirements of production operations needed to produce a product similar to the way the BOM lists the raw materials and components requirements. Because of the use of actual information on requirements from different production operations rather than historical estimates this method is more accurate than the previous. It again does not take lead times into account making it inaccurate for changing production mixes.

RCCP using the resource profile

This approach is similar to the previous approach using the BOL but it also takes the lead time into account by offsetting the capacity requirements into earlier weeks depending on this. It is therefore the most accurate approach. The lead time makes the calculations more difficult as the needs of a certain week are based on the MPS for that week and perhaps several different weeks ahead due to the offset. Inaccuracy in the approach stems from situations when the actual production lots do not correspond with the MPS quantities.

Capacity Requirements Planning (CRP)³⁶

CRP provides more detail and support for the MRP. It looks specific products and even subassemblies and their capacity requirements with regards to raw materials and components as well. Production routing also provides the ability to consider sequencing, batch sizes, and setups allowing for a more

³⁵ Based on Tenhiälä, 2011

³⁶ Tenhiälä, 2011

efficient production plan. Manual iterations are generally used for revising the plans, often requiring a large amount of them.

In batch production (Figure 6) orders are more repetitive and resources are more specialized, meaning that the maintenance of data pertaining to specific resources is of more importance. There is also a need to consider different routings in the planning process.

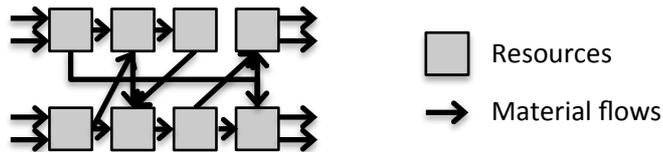


Figure 6. Batch production.³⁷

Finite-loading³⁸

Finite-loading generally tends to automate the iterations previously described. It uses algorithms to automatically schedule production so as not to exceed capacity constraints while ensuring minimal failure to meet due dates. This automation reduces the chance of human error. The method can be extended to complement the capacity leveling with optimization to minimize setups and downtimes for example. The method requires an extensive array of parameters to define the production and ensuring the accuracy of these is crucial in the resulting quality of the plan. Due to the level of detail the method supports the I/O control process.

In a batch production with a stationary bottleneck (Figure 7) the complexity is reduced which means that the finite loading method can be applied. This is because when there is no stationary bottleneck the finite loading of one resource may move the bottleneck to another resource. The iterative revision of the plan could potentially enter an endless state.

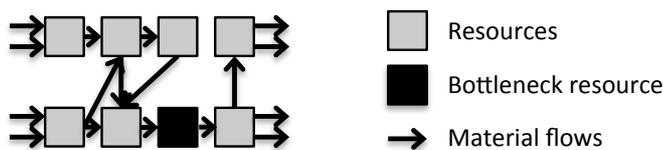


Figure 7. Batch production with a stationary bottleneck.³⁹

³⁷ Based on Tenhiälä, 2011

³⁸ Tenhiälä, 2011

³⁹ Based on Tenhiälä, 2011

The finite loading is most suitable for a line production (Figure 8). The flow through the line is defined by the bottleneck, ensuring that the finite loading is performed here only. The form of detailed planning and optimization allowed by the method is desirable to minimize changeover times in when the production volume tends to be high. The low variety of the production promotes the method, as the amount of parameters to maintain remains low.

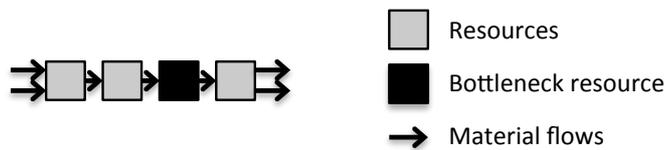


Figure 8. Line production.⁴⁰

3.2 Theory of Constraint

Theory of Constraint (TOC) is a production management system introduced by Dr. Eliyahu Goldratt. It has evolved from a scheduling tool into a management philosophy of continuous improvement since its introduction in 1979, and can be defined as an approach that aims to continuously improve performance of a production by focusing on improving the bottleneck processes of that production⁴¹.

In order to achieve change it is necessary to answer the following three questions.

- **What to change?**

With the amount of issues facing manufacturing it is important to find the change to make that will cause the best effect. This can be solving a problem or making an improvement.

- **To what to change to?**

Once a decision is made on which problem to address and what the core of the problem is, a solution needs to be found.

- **How to cause the change?**

When a solution is found it must be translated into a practical plan. This plan must deal with the time, effort, and capital required as well as frequent resistance to change from employees.⁴²

⁴⁰ Based on Tenhiälä, 2011

⁴¹ Verma, 1997

⁴² Ibid

In order to answer these questions Goldratt introduced a Five Focusing Steps (5FS) heuristic, which is a simple method of implementing the TOC practice.⁴³

Step 1. Identify the system's bottlenecks

This is the basis of TOC. The bottleneck of the system determines the throughput of the system.

Step 2. Decide how to exploit the bottlenecks.

Exploiting the bottleneck results in maximizing the entire systems throughput given its constraints.

Step 3. Subordinate everything else to the above decision.

The rest of the production should focus on maintaining high utilization of the bottleneck. This essentially means planning the rest of the production so that the bottleneck has maximum utilization without unnecessary work in progress elsewhere in the system.

Step 4. Elevate the system's bottlenecks.

Should the throughput of the bottleneck be insufficient capacity needs to be added to it.

Step 5. If, in a previous step, a bottleneck has been broken go back to Step 1.

This step leads to continuous improvement prompting the restart of the process. Elevating the capacity of the bottlenecks may create new bottlenecks.

3.3 Machine Grouping

To get from raw material to a finished products it requires one or more process steps normally carried out by machinery and labor. The flow between these processes could be organized in different ways depending on the type of manufacturer. There are three types of production setups that are normally used; line, cellular, or functional setups. The method of grouping the machines may increase the efficiency and total utilization of the machine park if suited to the nature of the products being produced. It is also common that manufacturers use a mixture of these setups.

3.3.1 Line production⁴⁴

The line production is a setup where the machines are grouped in the sequence for which they are used in a processing a specific product. By this reason the setups could also be called product layout and an example of the setup is shown in Figure 9. This kind of machine arrangement is suitable for continuous production of high quantities. The line production could be divided into two different types of lines, steering and floating line. In steering lines all processes will mechanically be controlled to keep same speed. The floating line does not have this kind of forced control and the material buffers are allowed.

⁴³ Verma, 1997

⁴⁴ Mattson & Johnsson, 2005

The benefit with this kind of setup is that the time required through the production line could be short. The mayor disadvantage is that if one machine within the line stops the whole line need to be stopped. By attempt to have buffers before all processes the production balance could be better.

3.3.2 Cellular manufacturing⁴⁵

The cellular manufacturing is one way of grouping machines for producing groups of products with close similarities with regards to production and design. The machines in that group are placed closed together and are dedicated to a group of products as shown in Figure 9. Each cell consists of necessary machines to ideally complete the articles within the product group to which is dedicated.

The benefits with this type of production setup is that the machines that are dedicated to products are close to each other, which will lower the transportation time of the batches between the production steps. Products with similar production settings could be placed after each other if they use the same machine, which will minimize the setup time. This type of setup is also ideally for a computerized production.

On the other hand the disadvantages of this kind of machine setups could also be discussed. First of all it normally incurs a high investment that is needed for the re-planning of machinery and any new equipment that must be purchased. The grouping into cells could also lead to disadvantages if new products that are introduced cannot be produced in the existing cells.

3.3.3 Functional manufacturing⁴⁶

Functional manufacturing is another type of workstation design where machines are arranged into functional groups with machines of similar characteristics, where a product jobbed by any machine in this group. By grouping the machines in this way the production will be stronger against breakdowns, as the total production do not need to be stopped. This kind of setup is also very useful for production of low demand products together with high demand products, because the utilization of the machines could be kept high. The functional layout is shown in Figure 9 and describes the flow of the products.

A possible benefit with introducing functional manufacturing is the ability to achieve a better balance in production and increases in productivity. The main costs is associated with the implementing of the system in an existing production facility, due to the necessary reorganization of machines into cells as in cellular manufacturing. It is also important to consider that the loss of production hours during implementation of the new setup could be very high.

⁴⁵ Shahrukh, 1999

⁴⁶ Shahrukh, 1999

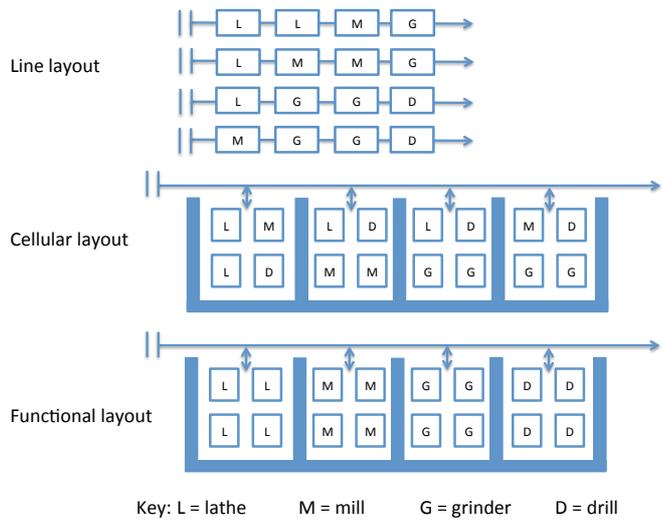


Figure 9. The figure describes the three different ways of grouping machines; line production, cellular grouping, and functional grouping.⁴⁷

3.4 Process Implementation

To successfully implement a new process requires the right knowledge, preparation, resources, time, and also a strong will from all involved. The implementation could be divided into four steps; defining the initial state and creating a project team, planning for the process implementation, executing the process implantation, and evaluate the process implementation. These four steps are shown in Figure 10 and are described below.⁴⁸

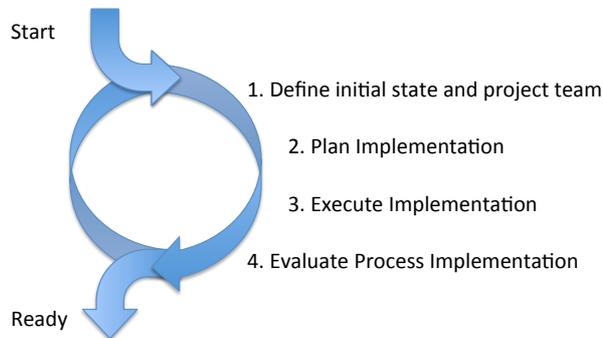


Figure 10. Four steps for implementing a new process⁴⁹

⁴⁷ Based on Shahrukh, 1999

⁴⁸ Based on James C. Helm, 2001

⁴⁹ Based on James C. Helm, 2001

3.4.1 Define initial state and project team

The first step in implementing a new process is to get a sharp understanding of how the organization is currently operating and what tools are in use. This also includes what kind of people that are working there, with regards to their competence and motivation. Then the current problems in the organization are identified and potential improvements are developed. The project team leading the implementation should be created and their different responsibilities should be determined.⁵⁰

3.4.2 Plan process implementation

Step two is to establish a plan for the implementation that should include all tasks required, the resources needed and the timeframe for each task. The plan should constantly be reviewed and changed if needed. During the implementation time all progress should be followed up to see if the plan should be modified to make sure the project is moving towards its goal.⁵¹

The goals for the project should be set, such as how the process will work when the implementation is completed. Before the actual process can be implemented the project team has to make sure that all involved managers support the project. Well-prepared documents and presentations should be used to explain all benefits with the new processes for them and the company. Process implementation guidelines should be used to give a clear view how the actual implementation will be executed. All risks in the project should be taken into account.⁵²

3.4.3 Execute process implementation

Before the actual process implementation could be start it is recommended that using a smaller group for a pilot to make sure that people will understand and make the actual rollout smoother and better. The feedback from the pilot should be taken into account to improve how the implementation should be proceeding. When starting the actual rollout the revised presentations and material are presented and the training starts.⁵³

3.4.4 Evaluate process implementation

Normally when introducing new processes there are complications in the implementation and it is of great importance that these are considered, so that the process can be modified and improved. A process implementation is not fulfilled successfully if people are not following the new process, so it is critical to ensure that processes is followed and also in a satisfying way. The processes should be continuously improved both during the implementation and after to make sure it is updated.⁵⁴

⁵⁰ James C. Helm, 2001

⁵¹ Ibid

⁵² Sheard, 2003

⁵³ James C. Helm, 2001

⁵⁴ Ibid

3.5 Supplier Relations⁵⁵

Today's businesses normally have a strategy that includes having several outside companies deliver goods and services. These suppliers are of great importance for how the companies' performance will develop. Normally companies prioritize to keep the activities that they are best at in-house and remaining will be outsourced to company specialized in these kind of products or services. In this way the company can keep their focus on its core processes. In order to obtain a first class-performance for a company it is important that their suppliers have a first class performance as well.

There are different ways for a company to handle their suppliers, which depends on what kind of risk that is related with the specific suppliers products or services. The risk could be associated with how many available suppliers it is on the market, time to develop new suppliers and if the product is vital for the company or not. If a product is easy to find by sourcing from other suppliers the risk will be low. Products that are vital for the company and where it is hard or takes long time to develop new suppliers, the products can be seen as having a higher risk. The relationships that a company could have with their suppliers could be divided into three steps as shown in Figure 11.

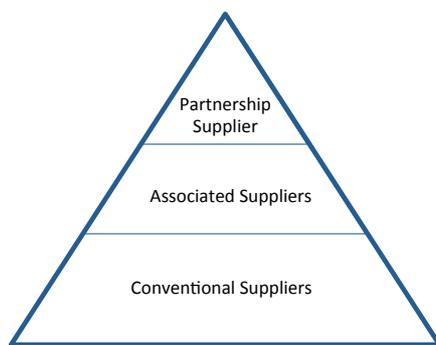


Figure 11. Three different levels of customer-supplier relationships. ⁵⁶

The pyramid shows different grades of customer-supplier relationships and each step has its specific strategies on how to handle the supplier.

The suppliers at the lowest level of the pyramid are the conventional suppliers. The relationship to these suppliers is characterized by the price being the main factors of deciding on a supplier, and the company usually keeps a safety stock to handle supply disruptions. The conventional suppliers could be divided into two different kinds; those with frequent orders and those with infrequent orders.

⁵⁵ Mattson & Johnsson, 2005

⁵⁶ Based on Mattson & Johnsson, 2005

Next level in the relationship pyramid is the associated suppliers where they characterizes by a longer relationships and closer cooperation. Together they try to shorten the lead-times and stock costs by synchronizing product flows. For this kind of suppliers price is just one assessment variable when choosing a supplier.

The top part of the relationship pyramid is partnership suppliers, where all is included from the associated suppliers but the relation is even deeper. In this kind of relation suppliers will be included in product development, frequent information exchange, and quality questions. In this kind of relationships investments in new equipment could be funded together or by the company because of the long relationships. Normally very long contracts are written to secure a healthy relationship.

To keep a relationship in a higher level there is a need for a lot of time and cost efforts to maintain the supplier in the high level. It is normally too costly to keep all suppliers in the higher level of relationships and it is not necessary if the products from that supplier aren't an essential for the company's success. By concentrating on the suppliers where highest volume, biggest profits and suppliers that help with the technical development, the company could keep the costs down. It has been shown that 20% of commodities suppliers stands for 80% of the total spending (the 80-20 rule).

4 One Supplier Capacity Process⁵⁷

In this chapter the One Supplier Capacity Process is presented, focusing on the framework for implementing it and calculating capacities.

This is a description of the One Supplier Capacity Process (OSCP), a process designed by the Plan & Secure Capacity process within IKEA. This process will help IKEA to archive the overall goal that is to have one common way of working. The method will standardize the way they are working with capacities in order to provide the ability to centrally aggregate the total accurate capacities of all IKEA suppliers worldwide as well as provide the local Trading Areas with a decision making framework.

The key to the process is to within IKEA work with all capacities in pieces of finished goods and work on group level with regards to products and production resources. It also provides a decision-making framework that contains predefined symptoms of problems, providing diagnosis and prescriptions. This framework is however not investigated in the thesis and is therefore not explained in this section.

There are three main goals for the process. The first is to contribute to better availability. This is to be achieved through accurate capacity figures, a proactive way of solving potential capacity issues both operationally and tactically, and the possibility to aggregate and follow up capacities on HFB and Category level through the common measurement being pieces.

The second goal is to reduce supply chain costs. This is to be achieved by having a global overview that will enable better utilization of suppliers through improved allocation possibilities, support in management of risk through the decision making framework, and better planning of downstream flows by reducing bullwhip effects from previously unforeseen capacity issues.

The third goal is the soft factors. The tools presented in the OSCP should provide a simple framework to help Trading Areas with working with capacities proactively instead of firefighting, increasing their motivation. It also provides a framework for working together across functions by defining responsibilities.

The operational capacity figures should be revised three times a year and for certain events, to keep the data updated to changes.

4.1 Key components of the One Supplier Capacity Process

The One Supplier Capacity Process uses many clearly defined components in order to insure that all who

⁵⁷ Björnsson, 2012

use the process will speak a common language. Most components relate to ideas needed to understand the method in which capacities are to be calculated. Other components are used to evaluate the capacities and connect them to the decision-making framework. The relationship between the first five components is depicted in Figure 12 below

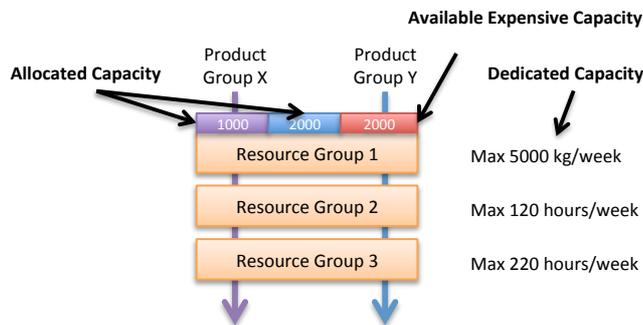


Figure 12. Key OSCP components and their relationship⁵⁸

Resource Groups

The definition of a Resource Group is a group consisting of production resources that have similar characteristics. A Resource Group provides capacity and is defined locally by TAs.

Product Groups

Product Groups are defined as a group of articles that have similar characteristics and share the same Resource Group or Groups. Product Groups consume capacity. They should be restricted to containing articles from one Segment and one HFB, and are globally defined by IoS for all connected suppliers.

Dedicated Supplier Capacity

The Dedicated Supplier Capacity is defined as the capacity of a Resource Group that is dedicated to IKEA for a given time period. It is dimensioned as the total local capacity need for the connected Product Groups and can be defined in any unit of measurement. The Business Developers are responsible for dedicating capacity.

⁵⁸ Based on Björnsson, 2012

Allocated Supplier Capacity

The Allocated Supplier Capacity is defined as the capacity that is allocated to a given Product Group within a given Resource Group. It is dimensioned as the capacity need of a Resource Group by a Product Group. The Supply Planners are responsible for allocating capacity.

Available Expensive Supplier Capacity

The Dedicated Supplier Capacity that is not allocated within a Resource Group is referred to as Available Expensive Capacity, as it is unutilized.

Available Supplier Capacity

Capacity in a Resource Group that is available but not dedicated to either IKEA or other customers is defined as Available Supplier Capacity (Figure 13).

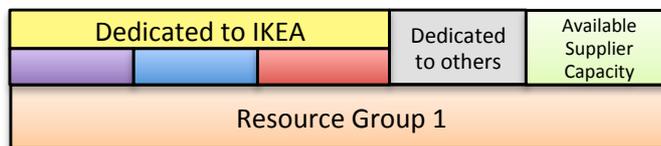


Figure 13. Available Supplier Capacity⁵⁹

Net Supplier Capacity

The sum of all the Dedicated and Available Supplier Capacities within a given time period is the Net Supplier Capacity.

Max Supplier Capacity

The Max Supplier Capacity is defined as the theoretical capacity of a Resource Group within a given time period. This is based on a constant production 24 hours a day 365 days a year.

Supplier Capacity Value

The Supplier Capacity Value is the capacity determined for a Product Group as the Allocated Capacity within a bottleneck (Figure 14). The bottleneck is where a single or a number of Resource Groups limits the performance of the entire production system. The capacity is translated into pieces for a given time period by multiplying the Allocated Capacity for each respective Product Group in the bottleneck by the consumption rate of that Product Group.

⁵⁹ Based on Björnsson, 2012

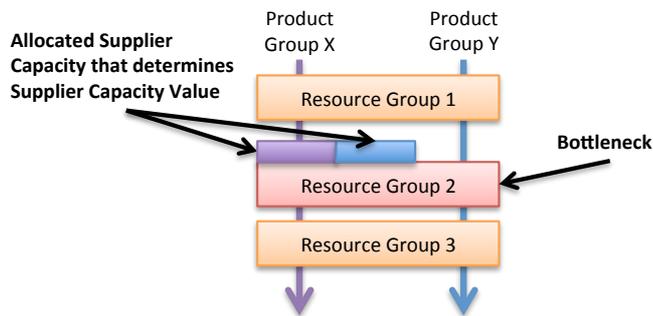


Figure 14. Depiction of Supplier Capacity Value⁶⁰

Supplier Capacity Type

The Supplier Capacity Type, or bottleneck type, identifies the factor that causes the bottleneck Resource Group for a Product Group. There are 10 predefined types, each with an identifying code, as shown below:

- 01 Component
- 02 Raw material
- 03 Labor
- 04 Electricity
- 05 Machinery
- 06 Tool
- 07 Packing
- 08 Storage
- 09 Maintenance
- 10 Others

Supplier Capacity Value Name

The name to be entered into the Global Purchasing System (GPS) and used to maintain capacities for each Product Group is the Supplier Capacity Value Name. It consists of the Product Group name, bottleneck Resource Group name, and bottleneck type. Each of these items is separated by a semicolon (;).

4.2 Method of calculating capacity

A 6-step procedure explains how the process is to be implemented. It is explained through 8 example reference cases of varying complexity.

Step 1. Define Resource Group/Groups

The first step is to define all the Resource Groups connected to a certain production system.

⁶⁰ Based on Björnsson, 2012

Step 2. Define Product Group/Groups and connect article/articles

Articles connected to a certain production system are identified and grouped as previously explained.

Step 3. Connect Product Group to Resource Group/Groups

A map is drawn up connecting all Product Groups to their relevant Resource Groups within a production system.

Step 4. Identify system bottleneck

A general evaluation of the production system by the supplier is performed to determine the possible bottleneck Resource Group or Groups.

Step 5. Calculate local need/capacity and check value

The weekly forecasted need for the end products is translated into a total need for capacity in in the bottleneck and the value is checked against the weekly capacity of that bottleneck. For two products sharing a bottleneck a graphic depiction is used to show how the capacity can be allocated between them (Figure 15).

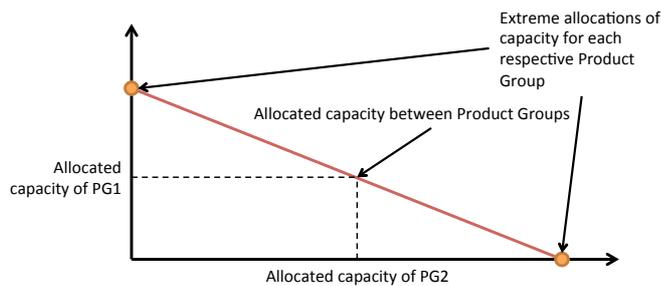


Figure 15. Graphic depiction of how the bottleneck's capacity can be allocated between two Product Groups. The allocation can lie along the red line.⁶¹

Step 6. Update the system

The final step is to determine the Supplier Capacity Value Name and update the internal system with the new name and new capacity figures.

4.3 Method of evaluating capacity

The relationship between the following four components is the key to applying the decision-making framework. This framework will not be presented in this thesis as it lies outside the scope.

⁶¹ Based on Björnsson, 2012

Planned Need

The Planned Need is the forecasted need of a Product Group from a certain supplier. This is based on the Supply Plan Information (SPI), an unconstrained need forecast that is distributed to suppliers.

Demonstrated Need

The Demonstrated Need is the actual need based on issued orders of Product Groups for each supplier.

Planned Capacity

The Planned Capacity is the previously mentioned Supplier Capacity Value for a Product Group for a supplier.

Demonstrated Capacity

The Demonstrated Need is the actual capacity based on notified deliveries of a Product Group for a supplier.

4.4 Plan for establishing the One Supplier Capacity Process

OSCP was developed through two separate projects, focusing on an operational process and a tactical process respectively. Each project involved the four phases; concept, pilot, evaluation, and analysis. These two were then merged into the final OSCP framework. The pilots were performed in July to October 2011 through the investigation of 93 suppliers standing for approximately 45% of IKEA's purchase value. The plan for the implementation is a successive rollout for a new category and trading area in accordance to the figure below:

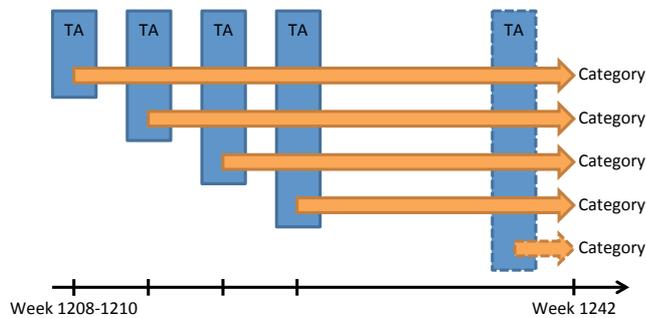


Figure 16. Timeframe for the implementation of OSCP.⁶²

⁶² Based on Björnsson, 2012

5 IKEA Trading's Current Way of Working

This chapter presents the plastic category within IKEA's Trading Area Greater China and their way of working with capacities, based on interviews and observations of employees.

The plastic category is one of the bigger ones within IKEA with totally 1591 articles crossing 15 HFB. The category is characterized by long lead-times and huge investments when new machines and tools are needed to increase the output.

5.1 Capacity Groups

The products today are grouped mainly according to tools, because that is what is normally viewed as the bottleneck. The decision about how to group lies with the responsible SP together with the supplier, and the naming of the group is the SPs responsibility. The product groups and names are uniform within China, but the Chinese TA is not sure about how other countries groups are.

5.2 Capacities in GPS

Currently IKEA maintains its capacity figures in the GPS software, which allows only the maintenance of one figure. The capacities entered to GPS are always registered in pieces and are 100% of the capacity. The numbers are determined by suppliers and inserted to the system by the SP. The capacities are updated 2-3 times a year for most products, but for certain products the capacities is updated 4-5 times per year and some monthly. The TA perceives the current accuracy of the capacity numbers to be good. The capacities inserted to the GPS are operational, and they try to maintain tactical figures, but this is only done for the critical products.

5.3 Working With Capacities

5.3.1 Operationally

The TA's key operational task with regards to capacities is to continuously check the capacities compared to what they order are and will not take any actions if the orders are below the registered capacity. If the orders are higher for a short time period the SP will ask the supplier to start frontloading to prepare for the upcoming orders. When having very high orders or high orders for a longer time where there is not enough storage space to frontload to meet the upcoming orders the SP will lock the orders in the system to a level that could be delivered. The remaining part of the orders will be sent to other suppliers producing that product if there are any by the need planner. This suppliers need to be in a reasonably close area to be able to get the orders, because of customer location and transportation costs. If orders are higher than the capacity at the supplier and they have not frontloaded enough a cancelation of the order

will be made, which means that the supplier will just deliver the amount that it has on hand. This will create high fluctuations in the SPI that makes it either harder to foresee upcoming order quantities.

If the supplier delivers more than the capacities figures shows in GPS, trading will investigate the reasons why. The explanations could be more working hours, changed cycle times, overtime, or safety stocks.

5.3.2 Tactically

If orders will not decrease during a longer time period the SP, BD, and supplier will start discussing about investment in new tools or/and machines. The tool investments are always funded by IKEA and in some rare cases they will help to invest in machines for the suppliers. When IKEA invests in machines at suppliers they usually have a long-term contract and the supplier will then pay off that in a defined timeframe. The times from the proposal of new tools or machines to when they are ready for use takes on average about six months. Normally decisions to invest in new tools are taken when orders cannot be met during a longer time period. The main reason that the decision is taken this late is because of the lack of confidence in the SPI. They do not rely on its actual figures and will not take decisions to invest in new tools or/and machines even if they can see that the future SPI will be above the capacities, because of its huge investments and risks. When ordering new tools or machines the supplier will deliver max capacities until the machines are in place and the bottleneck is changed or improved. Because of high fluctuations in the SPI, SP will also not take any kind of action before it is less than 2 months before actual order.

In some cases decisions of new tools or machines could be decided by discovering strong increases in the SPI. SP and BD will then discuss and send a proposal concerning the investment with IoS that will need to verify that the increase in the SPI is reliable.

6 One Supplier Capacity Process Implementation

This chapter presents an initial insight into the suppliers' productions. It describes the plastic production generally using terms from the OSCP process, and depicts four situations that need solving in order to effectively implement the process to calculate the capacities. The Product Groups predefined by IoS are also discussed.

6.1 General Description of the Investigated Plastic Productions

The products investigated in this thesis are categorized by IKEA in three types; one-shot products, products requiring assembly, and technical products. All productions are centered on one or more injection machines. Raw material is fed into the machine, and one or more pieces are produced there using a tool specific for that piece. Injection machines are rated in tonnage expressing the exerted clamping force in the machine. Each tool has a minimum clamping force meaning that it can be used in machines of a certain size or larger, but the use of the minimum size machine is preferred from a cost perspective.

For one-shot items the piece or pieces are packed either alone or with other pieces (Figure 17). For products requiring assembly the pieces are assembled together and then packed. Common variations to this include the addition of components, and the use of another form of machine (Figure 18). Technical products are produced similarly to assembly products or one-shot products but require advanced machines such as over-mold machines and bristling machines for brushes.

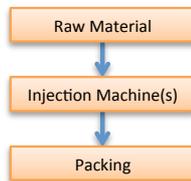


Figure 17. One-shot production

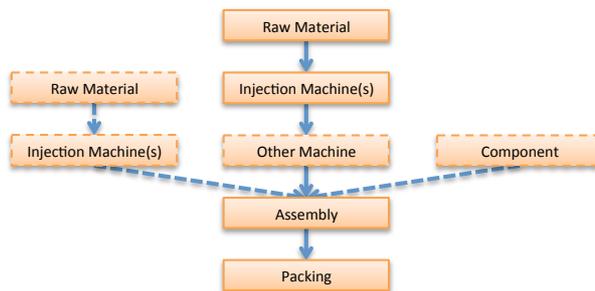


Figure 18. Assembly production.

The assembly and packing comprises of manual labor on the most part in the productions investigated. In some exceptions support machines are used. Because of the high availability of cheap labor in China the suppliers generally dimension the capacities so that these resources are not bottlenecks. The event in which there may be an exception to this is in the immediate period surrounding Chinese New Year. During this weeklong holiday many Chinese travel to their hometowns to meet their families, and because of the expansion of industry throughout China some find jobs closer to home and therefore do not return⁶³. Time is therefore needed to fill these vacancies.

The raw materials are ordered by the suppliers based on the SPI provided to them by IKEA. The major raw material suppliers require a two month need forecast, and weekly the actual amount needed is ordered and delivered with a one week lead time. The actual orders can contractually only deviate 20% from this need forecast.

For these reasons the suppliers within the plastic category tend to have a clearly identified bottleneck being the injection machines and the tools used in them. The reasoning for this is that these machines and tools tend to be the most expensive investments. As a result suppliers generally determine capacities by looking at tooling capacity without regard for the allocation of machine hours to these tools. In their production plan they do however perform an allocation of tools to machines. The capacities are therefore most often determined by the cycle time for a tool in a machine multiplied by a certain amount of weekly production hours.

6.2 Production Situations

There are four general situations that the various Product Groups belong to depending on the complexity of the production and the way in which the production resources are shared.

6.2.1 Situation 1 – One Product Group per production line

This is the simplest situation where an entire production line is dedicated to a single Product Group. An example is the Product Group Lekman which is produced in a dedicated line at the supplier B. It consists of two different raw material Resource Groups and two different injection machines Resource Groups followed by a packing Resource Group. The bottleneck is the group of injection machines producing the front and back panel. This is shown in the Figure 19.

⁶³ Supplier 19720

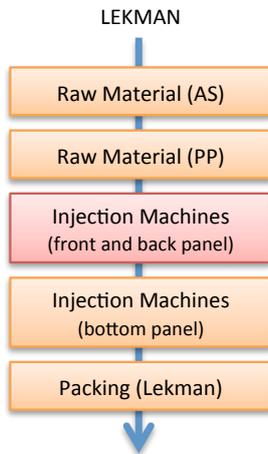


Figure 19. Situation 1 reference example (Lekman produced at B).

6.2.2 Situation 2 – One Resource Group is a shared bottleneck for several Product Groups

This is again a simple situation. It is where several Product Groups share one or more entire Resource Groups, and where one Resource Group shared by all in this system is the bottleneck. It is the bottleneck when capacity is calculated given the need from the SPI and remains the bottleneck when the maximum capacity is calculated with regards to this need.

An example is the production of the Product Groups Rufsfig Kitchen Utensils S2 and Rufsfig Wok Utensils S2 at the supplier B. They share raw materials, one injection machine, and assembly line (Figure 20). This injection machine is viewed as the bottleneck.

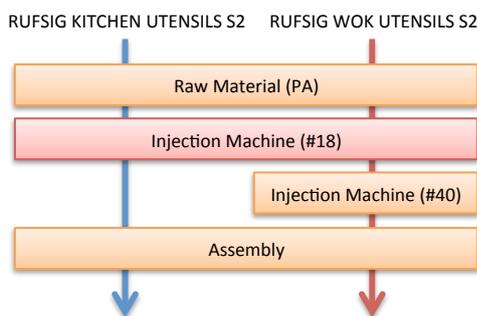


Figure 20. Situation 2 reference example (Rufsfig Kitchen Utensils S2 and Rufsfig Wok Utensils S2).

6.2.3 Situation 3 – Multiple Resource Group bottlenecks in a production

In this situation there is more than one bottleneck Resource Group within a system. Due to the complexity of the sharing of Resource Groups the identification of the bottleneck is sometimes difficult. An example of this situation is depicted in the B reference case in Appendix B.

6.2.4 Situation 4 – Partial sharing of Resource Groups

Sometimes there are cases when one or more, but not all, specific resources in a parallel Resource Group for one Product Group is being shared with another Product Group. An example is the production of the Tolsby Frame at B. It uses four machines to make one component of the end product, and only one of these machines is shared with the Fantastisk Napkin Holder, as depicted in the figure below.

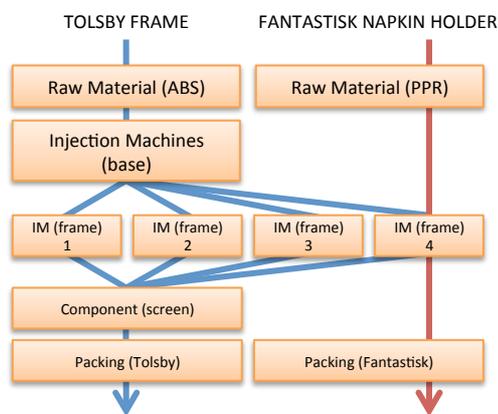


Figure 21. Reference example depicting the complication in Situation 4 (Tolsby Frame and Fantastisk Napkin Holder produced at B).

6.3 OSCP Product Groups

The job of defining and naming the Product Groups within a category lies with its category leader from IoS. In the plastic category the Product Groups are defined by the tools they use, because each is custom made for a specific part. All articles within a Product Group consist of identical parts with the exception of the color of these parts. This is because it is assumed that the difference in production between different colors is so miniscule that it can be disregarded. The addition of a small amount of the material masterbatch is usually responsible for determining the color, and suppliers don't experience shortages in the availability of this material. The changing of colors in an injection does however require cleaning of the machine reducing the amount of machine hours available for production. For some products such as the Raffig hook produced at H one color is a result of a coating process (see reference case H).

In most instances articles of varying colors are sold separately, but sometimes articles are sold in sets of individual pieces of different colors. An example of this is the Smaska Bowl that is sold in a set of three

different colors. It is produced at G (see Appendix G) and their practice is to produce the three colors parallel in three different machines and assemble immediately.

Another difference between some articles within a Product Group is the labels that are put on them. This is dependent upon the region in which the articles are sold. The only other difference experienced by the authors is that on one version of the Antilop Highchair the safety belt is factory assembled and on the other it is not, again depending on the region in which it is sold.

7 The Development of the Template

In order to apply the OSCP process to plastic production an initial analysis is made of the its implementation method as well as the suppliers productions. The experienced lack of tools and clear procedure is the basis for the development of the template used as the key tool to apply the process to the suppliers visited in a structured manner.

7.1 Initial Analysis of the One Supplier Capacity Process Method of Implementation

There is a difficulty in defining the initial state in the implementation of a process such as this, as the process is standardized and to be implemented on several different suppliers with vastly different products and productions. An investigation into plastic production with regards to determining capacities was not performed prior to the rollout of the process. As a result the immediate realization upon visiting the suppliers was that OSCP provides no concrete plan of how to determine the suppliers' capacities. The method steps presented through the use of reference cases (section 4.2) are quite unclear and the cases themselves are all relatively very simple compared to many of the production systems investigated, addressing only the first two situations discussed in section 6.2. There is no structured way of identifying the bottleneck described, and there is also no guidance for determining consumption rates for different forms of Resource Groups, which was especially difficult when several production resources perform the same part for a product but in a different manner.

The purpose of the first supplier visits together with the project team from IoS was to gain an understanding of the plastic production in China through the investigation of the two biggest suppliers with different levels of production complexities and dedications to IKEA. However, the productions witnessed during these visits only presented the same simple situations as the OSCP reference cases, and provided little insight into the current working methods with regards to capacity determination. The initial interpretation that the complexity would not exceed that of these situations led to a lack of preparedness for the more difficult ones.

The second visit to B and A essentially followed the four step procedure for process implementation discussed in section 3.4. The initial state had been investigated, although insufficiently, and a very basic initial template was developed as a plan for the implementation of the process on all Product Groups. This was in order to minimize the burden for suppliers and IKEA employees to implement the process, which might minimize their incentive to use it.

The implementation during this second visit provided a clearer understanding of the complexities of plastic production with regards to the implementation of OSCP, and from the evaluation of this the first

version of the complete template in its final form was developed. The implementation at B and A can essentially be seen as a pilot for the implementation of OSCP specifically for the plastic Category. This template was successively updated following each new complication investigated at the suppliers. It follows steps that are thoroughly explained in the template instructions (see Appendix K and Appendix L) and only summarized in this section.

7.2 The Template Developed for the Implementation

The introduction of the template to the suppliers was performed in specific way. The complete template with the data collection and data analysis sections were sent to them prior to the supplier visits, but they were only required to complete the former. The latter was sent in order to give the supplier time to familiarize themselves with it, and it was thoroughly presented during the visits.

7.2.1 Data Collection

The first step is to investigate the production resources linked to a certain Product Group, and they are listed and relevant information is collected. For raw materials and components the amount per end product is entered. For machine and manual labor includes the amount of machines or laborers, cycle times, the contribution to end pieces of a cycle, the dedicated weekly capacity, and a downtime rate. The latter two are used to determine the dedicated supplier capacity of a production resource. The allocation of tools to machines is based on the suppliers production plan.

7.2.1.1 Dedicated Supplier Capacity

As the supplier visits revealed a lack of suppliers understanding of what net capacity is, a standardized method of determining the net capacity of each machine dedicated to IKEA was developed. Most suppliers have a common figure for the daily production time for all their machines taking into account power cuts and planned maintenance, essentially providing figures for the nominal capacity. In order to arrive at the gross capacity other downtime such as tool and color changes and breakdowns needs consideration. Although tool and color changes are planned events they occur irregularly and affect only certain machines in different ways. It is therefore advisable not to include this in the weekly capacity figure but rather in a downtime rate together with other unplanned events (Figure 22). In this way most Resource Groups will have a common weekly capacity and only the downtime rate will need regular updating.

As for determining the gross capacity of labor resources this was not thoroughly investigated in this thesis. This is because there is a general lack of consideration taken for labor by the suppliers as they never experience this as a bottleneck and therefore there is a lack of information pertaining to capacity loss. The nominal capacity takes into account only the length of the shifts and downtime rate is essentially the time

spent on breaks. To arrive at the net capacity a defect rate is used to take all manner of rework and capacity losses due to defect products or parts into account (Figure 22).

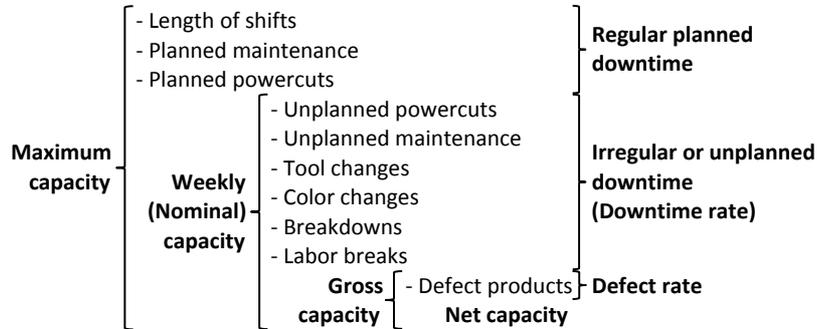


Figure 22. Factors affecting capacity and how they are considered in the template.

7.2.2 Data Analysis

7.2.2.1 Resource Groups

The next step is to determine how to group resources and calculate consumption rates for the groups. If one or more resources are used for a specific job and are identical in terms of cycle time and amount of pieces produced per cycle they are immediately grouped as a conceptual unique resource (UR). These unique resources are grouped together into Resource Groups in four ways each with a different method of calculating the group's consumption rate:

- **Type 1 - Single UR**
This is where a UR is ungrouped. The consumption rate is that of the UR.
- **Type 2 - Consecutive UR**
This is where several UR performing different jobs are grouped. The consumption rate for the group is that of the bottleneck UR in this group.
- **Type 3 - Parallel UR**
This is a group of UR performing the same job but in different ways. The consumption rate for the group is calculated as a weighted average (based on nominal capacity in pieces) of the individual rates of the URs in the group.
- **Type 4 - A combination of Consecutive and Parallel UR**
When consecutive and parallel groups are combined the consumption rate is calculated for the lowest level group first and then continuously for the aggregated groups.

The template provides tools for translating the cycle times into consumption rates for each of the first three groupings.

A decision was made by the TA and Category leader at IoS to use the following six generic types of Resource Group names as they cover most of the activities within plastic production:

- Raw material (RM)
- Injection machine (IM)
- Support machine (SM)
- Component (Comp)
- Assembly
- Packing

In order to differentiate between the different specific Resource Groups it was also decided to include a specifying name to the generic name, especially in instances where there was more than one of a certain type of Resource Group in a production system. This is for example the raw material type or injection machine number or part it makes.

In order to address the complications presented in Situation 4 (section 6.2.4) a solution was found. It is assumed that the Product Group using less the total amount of resources in a Resource Group can in fact use all the resources. A new Resource Group is added that constrains that Product Group. In the case of plastic production this second Resource Group is usually the tool. If the template tries to allocate more hours than one machine can provide the tool capacity will constrain it. The Tolsby and Fantastisk example is shown in Figure 23. It is assumed that the Fantastisk Napkin Holder can utilize the entire Injection Machine (frame) Resource Group but is then constrained by the Tool (Fantastisk) Resource Group. The consumption rate for the Fantastisk Napkin Holder is the same for these two Resource Groups, and the downtime rates should be the same. The difference is that the weekly capacity for the tool accounts for only one machine whereas the capacity for the injection machine group accounts for all four machines.

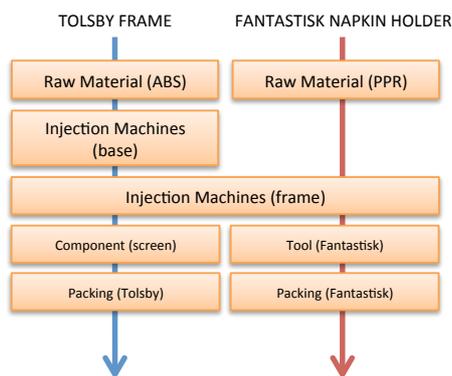


Figure 23. The solution for the Situation 4 example.

This solution should also be able to be used for cases not related to plastic production, but when the complication arises for other reasons.

7.2.2.2 Allocated Capacity

The material argues that the allocated capacity should cover average need of a Resource Group for each Product Group that uses it. As the capacity should reflect how much can be produced in a given time period the authors' deduction from this is that the total capacity in a Resource Group that is dedicated to IKEA should be allocated. This allocation is based on the average need and means that the capacities determined are never constant when allocation of the bottleneck is performed. Other weightings could be taken into regard such as service level and fluctuations, which might be especially important if the need exceeds the capacity.

In order to standardize the method of allocating capacity for Product Groups sharing critical Resource Groups based on need, the basis for this allocation is decided as the average forecasted need for 17 weeks starting outside the lead time plus one week in the future. This is a decision made by the category leader.

The template then follows the principles of rough-cut capacity planning using the Bill of Labor and Bill of Materials. This is done by calculating a need for capacity of a Resource Group by all Product Groups connected to it given the value for the forecasted need of each respective Product Group, taking into account the added need for the defective products. From this the utilization is determined for each Resource Group based on the previously determined dedicated net capacity. Here the ideas behind TOC come to use. The bottleneck Resource Groups are identified and theoretically exploited to their full potential in order to determine the maximum net capacity for the Product Groups. Dividing the need by the bottleneck utilization given the need does this.

In some cases, as discussed in Situation 3 (section 6.2.3) this does not result in a capacity that insures a 100% utilization of each Product Groups bottleneck, resulting in a capacity that is not the maximum allocated net capacity. An iterative procedure was developed to maximize all bottlenecks while maintaining the allocation based on the forecasted need. This is by increasing all capacity values for Product Groups with maximum utilization less than 100% by a common factor until each one successively reaches 100%.

8 The Specific Implementations on the Plastic Suppliers

This second empirical study looks at the specific suppliers visited and explains their productions along with a short summary of key points regarding the specific implementations of the OSCP process. The resulting capacities calculated through the use of the template are presented alongside the previously determined capacities.

8.1 Supplier A

A is one of IKEA's biggest suppliers within the plastic category in China in that they have totally 27 Product Groups in their production. Their production is 100% dedicated to IKEA, which means that IKEA has big power directing the supplier. They have both one-shot products but also a lot of more complicated production setups. Currently the demand is lower than normally and there are only two cases of sharing's. Through discussions and interviews with the responsible team for A they experience that higher demand will increase the complexity through more sharing's of production resources. The capacity today is calculated by determining the bottleneck machine for each product in each production line and then calculating the weekly maximum throughput of that product in that bottleneck. The hours per week used for the calculations is 24 hours per day 6 days a week, removing one workday in consideration for capacity losses due to factors such as power cuts and tool and color changes. The capacities calculated is the operational, what can be produced today. Tactical capacities are also managed by working out yearly business development plan or new investment plan. If there are orders higher than the capacity figures A will prepare inventory in advance, re-assign shared resources and secure a seven days production with generator to secure against power cuts.

Implementation

The biggest issues when implementing the new process was for one of the more complex setups with one Resource Group with two machines where both are used for one Product Group and only one of these is also used for another Product Group. Below in Table 1 the old and new Product Group names, capacities, and bottleneck utilizations given the forecasted need before and after the implementation are shown. The amount of bottlenecks and whether they are shared is also shown along with the bottleneck type and a specifying code for those that are shared. The downtime rate was calculated by adding actual historical data of the machine breakdown, tool breakdown, repair time, testing, and much more. The capacity hours per week (144 hours) used in the calculations of the capacities are defined as 24 hours per day 6 days a week.

Table 1. Results of the implementation for the supplier A.

	Old group name in GPS	Old GPS capacity (pieces)	New Product Group name	New capacity (pieces)	Capacity difference		Bottleneck			No of PG sharing resources	Forecasted need (pieces)		Utilization	
					(pieces)	(%)	Amount	Shared	Type and specifier		Before	After	Before	After
A	Antonius	25996	ANTONIUS_BASK_INSERT	26988	992	4%	1	no	im	1	12690	49%	47%	
	Bagis big black	39204	BAGIS_4P	39682	478	1%	1	no	im	1	23815	61%	60%	
	Bagis children	18005	BAGIS_8P	40982	22977	128%	1	no	im	1	12674	70%	31%	
	Boholmen colandar	31363	BOHOLMEN_COLANDER	31858	495	2%	1	no	im	1	10475	33%	33%	
	Boholmen wash-bowl	4704	BOHOLMEN_WASH_UP_BOWL	12266	7562	161%	1	no	im	1	2635	56%	21%	
	Boimen toil brush hldr	78821	BOLMEN_TOIL_BRUSH_HOL	98658	19837	25%	1	no	sm	1	60200	76%	61%	
	Boimen toilet seat	6428	BOLMEN_TOIL_SEAT	14757	8329	130%	1	no	im	1	2795	43%	19%	
	Boimen waste bin	15618	BOLMEN_WASTE_BIN_WITH_LID	15084	-534	-3%	1	no	im	1	7235	46%	48%	
	Bygel	120000	BYGEL_CONTAINER	134615	14615	12%	1	no	im	1	116432	97%	86%	
	Chosigt	19701	CHOSIGT_FUNNEL	20185	484	2%	1	no	im	1	13849	70%	69%	
	Diska	33943	DISKA_DISH_WASHING_BRUSH	31500	-2443	-7%	1	no	sm	1	2070	59%	64%	
	Flackig colander	30396	FLACKIG_COLANDER	34150	3754	12%	1	no	im	1	22026	72%	65%	
	Flackig jug	14702	FLACKIG_JUG_1L	13999	-703	-5%	1	no	im	1	12488	85%	89%	
	Flackig mixing bowl	10760	FLACKIG_MIX_BOWL	17459	6699	62%	1	no	im	1	5475	51%	31%	
	Flundra	20328	FLUNDRA_DISH_DRAINER	18440	-1888	-9%	1	no	im	1	15780	78%	86%	
	Kalás cutlery	81507	KALAS_CUTLERY	66316	-15191	-19%	1	no	im	1	45480	56%	69%	
	Kalás mug	109004	KALAS_MUG	131984	22980	21%	1	no	im	1	84812	78%	64%	
	Kalás bowl	99442	KALAS_BOWL	80412	-19030	-19%	1	no	im	3	54025	54%	67%	
	Kalás plate	67478	KALAS_PLATE	73911	6433	10%	1	no	im	1	41202	61%	56%	
	Plastis	58000	PLASTIS_DISH_WASHING_BRUSH	49887	-8113	-14%	1	no	im	1	50264	87%	101%	
	Pruta	100800	PRUTA_FOOD_SAVER_S17	67123	-33677	-33%	1	no	im	1	55000	55%	82%	
	Rationell Variera tray	59692	RATIONELL_V_CUT_TRAY_31X26	57238	-2454	-4%	1	no	im	1	34019	57%	59%	
	Reste rround	22402	RESTA_FOOD_SAVER_S5	9259	-13143	-59%	1	no	im	1	3134	14%	34%	
	Tokig	41196	TOKIG_SALAD_SPINNER	34019	-7177	-17%	2	yes	im(tn)/im(s)	3	15968	39%	47%	
	Boimen toil roll hldr	6055	BOLMEN_TOIL_ROLL HOLDER	13987	7932	131%	1	yes	im(s)	3	1312	22%	9%	
	Boimen bthr s3	7841	BOLMEN_S3	3999	-3842	-49%	1	yes	im(tn)	3	2520	32%	63%	

8.2 Supplier B

B is one of IKEA’s key suppliers within the Plastics category in China with regards to its 21 products in production. IKEA stands for 55% of B’s production turnover with the rest producing for other customers or the enterprise group of which it is a part. The types of products are both complicated products that require support machines, assembly, or more advanced packaging, as well as simple one-shot products. The layout of the factory is such that production lines are used for the more complicated products requiring support machines and one-shot items are produced in machines of the correct size where there is experienced available capacity. This means that the latter items are sometimes produced in machines belonging to the production lines of the former items.

B’s production strategy is to ensure that the injection machines are the bottlenecks. In their planning they group their injection machines based on size only and allocate tools to machines. The capacities provided to IKEA are the maximum tooling capacities regardless of machine hour allocations to these tools and machine dedications to IKEA. The weekly machine hours that are used to calculate capacities are 138 hours, taking into account only scheduled maintenance and power cuts. B collects information about defect rates but not about down times of the machines pertaining to breakdowns and tool changes.

Implementation

The implementation of the OSCP process resulted in B demonstrating the ability to use the template independently by creating the Resource Groups and connecting the Product Groups, as well as inserting the other relevant data such as downtimes and weekly forecasted need. They presented figures for the weekly capacity of their machine Resource Groups dedicated to IKEA, with the basis for the dedication being the demand from the SPI, allowing for a very slight arbitrary buffer. This is what B can promise to dedicate to IKEA. Because of the lack of statistical data pertaining to unplanned downtimes of their

machines they provided a standard figure of 4%. The following table summarizes the results of the implementation:

Table 2. Results of the implementation for the supplier B.

	Old group name in GPS	Old GPS capacity (pieces)	New Product Group name	New capacity (pieces)	Capacity difference		Bottleneck		No of PG sharing resources	Forecasted need (pieces)	Utilization		
					(pieces)	(%)	Amount	Shared			Type and specifier	Before	After
B	eriland	1082	ERILAND_CHAIR	536	-546	-50%	1	no	im	144	13%	27%	
	impuls	21977	IMPULS_JUG_W_LID_2L	13547	-8430	-38%	1	no	im	10697	49%	79%	
	Krus 2.4L	21560	KRUS_JAR_W_LID_2.4L	8964	-12596	-58%	1	no	im	840	4%	9%	
	samia 5SL	9590	SAMLA_5SL	4298	-5292	-55%	1	no	im	3617	38%	84%	
	samia 130L	5222	SAMLA_130L	2387	-2835	-54%	1	no	im	2009	38%	84%	
	Tobias	1248	TOBIAS_CHAIR	929	-319	-26%	1	no	im	472	38%	51%	
	Antilop chair	8791	ANTILOP_HIGHCHAIR	7755	-1036	-12%	1	no	im	5901	67%	76%	
	Brada laptop support	65930	BRADA	46860	-19070	-29%	1	yes	im(5,7,8,62)	46997	71%	100%	
	Fniiss	53958	FNISS_WASTEPAPER_BASKET	37056	-16902	-31%	1	yes	im(5,7,8,62)	35500	66%	96%	
	Antilop tray	9590	ANTILOP_TRAY	7056	-2534	-26%	1	yes	im(snille chr)	6042	63%	86%	
	Snille	19903	SNILLE_SEAT_SHELL	10920	-8983	-45%	1	yes	im(snille chr)	8291	42%	76%	
	Tolsby Frame	176452	TOLSBY_FRAME	154780	-21672	-12%	1	no	im	143000	81%	92%	
	Fantastisk	21977	FANTASTISK_NAPKIN HOLDER	17808	-4169	-19%	1	no	tool	7736	35%	43%	
	Kvill	19600	KVILL_FRAME_13X18	10612	-8988	-46%	1	yes	im(20)	10453	53%	99%	
	Kvill oval	19600	KVILL_FRAME_13X18_OVAL	6481	-13119	-67%	1	yes	im(20)	6738	34%	104%	
	UPPLEVA cbl	12172	UPPLEVA	7868	-4304	-35%	2	no	im/im	7750	64%	99%	
	samia 4SL	21609	SAMLA_4SL	12920	-8689	-40%	1	no	im	10255	48%	80%	
	samia 6SL	8114	SAMLA_6SL	3960	-4154	-51%	1	yes	im(1)	3902	48%	99%	
	samia 8SL	6593	SAMLA_BIN_WITH_LID_8SL	342	-6251	-95%	2	yes	im(11/im16)	338	5%	99%	
	samia 45/6SL lid	39069	SAMLA_LID_FOR_BOX_45/6SL	22356	-16713	-43%	1	yes	im(3,61)	13839	35%	62%	
	samia 55/130L lid	12558	SAMLA_LID_FOR_BOX_55/130L	5358	-7200	-57%	1	yes	im(16)	5221	42%	97%	
	Bolmen corner shelf	7889	BOLMEN_SHELF	6192	-1697	-22%	2	yes	im(3,61)/im	5521	70%	89%	
	rufsig kitchen ut s2	27720	RUFSIG_KITCHEN_UTENSILS_S2	10080	-17640	-64%	1	yes	im(18)	6435	23%	64%	
	rufsig wok s2	26372	RUFSIG_WOK_UTENSILS_S2	22800	-3572	-14%	1	yes	im(18)	14768	56%	65%	
	Bagis big white	84699	BAGIS_4P	82320	-2379	-3%	1	no	im	1	44988	53%	55%
	Bolmen stool	15070	BOLMEN_STOOL	16000	930	6%	1	no	im	1	16142	107%	101%
	Bursjön	8453	BURSJON_STOOL	4284	-4169	-49%	1	no	im	1	3103	37%	72%
	Lekman	33901	LEKMAN_BOX	25120	-8781	-26%	1	no	im	1	21336	63%	85%

B expressed their view that the process could help them in their production planning. One example they explained was the yearly resource planning and IKEA dedication that is currently performed based on experience and conjecture could greatly be improved through OSCP and the supporting template.

8.3 Supplier C

C is a rather small supplier for IKEA as at the time of the supplier visit they have only three Product Groups in their production that all share the assembly, packaging and the baking machine. The supplier has a shared production with other customers, but there is just a small amount of sharing in the specific machines that IKEA used. Mainly it is the baking machines that were shared for all Product Groups between IKEA and other customers to C. The products produced for IKEA are all in silicone with a production setup that is slightly different compared to the other suppliers. The production basically follows these steps; coloring the silicone, oil pressure (the product gets its shape), trimming, baking, and packing.

Implementation

The capacity per week is determined by 10 hours per day and six days per week, they also consider power cuts. The Product Groups and capacities before and after the implementation is shown below in Table 3.

Table 3. Results of the implementation for the supplier C.

	Old group name in GPS	Old GPS capacity (pieces)	New Product Group name	New capacity (pieces)	Capacity difference		Bottleneck			No of PG sharing resources	Forecasted need (pieces)	Utilization	
					(pieces)	(%)	Amount	Shared	Type and specifier			Before	After
C	STINN oven mitt	10047	STINN_OVEN_GLOVE	9575	-372	-4%	1	no	sm	1	18789	187%	194%
	SOCKERKAKA HEART	4800	SOCKERKAKA_BAK_MOULD_1.5L	4988	188	4%	1	no	sm	1	6150	128%	123%
	SOCKERKAKA MAT AND KNIFE	9600	SOCKERKAKA_BAK_MAT_KNIFE	8869	-731	-8%	1	no	sm	1	5294	55%	60%

8.4 Supplier D

D supplies only three Product Groups to IKEA. Although the supplier supplies other customers than IKEA, these products are all produced on injection machines completely dedicated to IKEA, and none of these are shared between the Product Groups. The weekly capacity is 126 hours taking into account planned maintenance and power cuts, as well as tool and color changes.

Implementation

D set both the defect and downtime rates at 1%. This is because they claim that their machines are brand new meaning that they very seldom break down or produce defect products. The results of the implementation at D are shown in the table below:

Table 4. Results of the implementation for the supplier D.

	Old group name in GPS	Old GPS capacity (pieces)	New Product Group name	New capacity (pieces)	Capacity difference		Bottleneck			No of PG sharing resources	Forecasted need (pieces)	Utilization	
					(pieces)	(%)	Amount	Shared	Type and specifier			Before	After
D	-	-	FIXA_DRILL	40420	-	-	1	no	im(18)	1	9700	-	24%
	-	-	EKBY_STÖDIS	167967	-	-	1	no	im(21,42)	1	77000	-	46%
	-	-	SAXNÄS_FRAME	11116	-	-	1	no	im(44)	1	1900	-	17%

8.5 Supplier E

E had at the supplier visit 8 Product Groups within their production. They had other customer besides IKEA but did not share the machine between these customers, which made the production pretty simple. They have both one shot products but also more complicated products with assembly. The current calculations of the capacity are done by determining the bottleneck and give the figures according to that throughput.

Implementation

The implementation of the new Products Groups and template made some small changes in the old structure. The Product Groups and capacities before and after the implementation are shown below in Table 5. The Product Groups for 365+ was before categorized by the lid and size of the lid as shown in the table. This was because they assumed that these were the bottlenecks. In the new calculations all parts are considered and a better picture of reality is shown.

Table 5. Results of the implementation for the supplier E.

	Old group name in GPS	Old GPS capacity (pieces)	New Product Group name	New capacity (pieces)	Capacity difference		Bottleneck			No of PG sharing resources	Forecasted need (pieces)	Utilization	
					(pieces)	(%)	Amount	Shared	Type and specifier			Before	After
E	365 25 x17	19196	IKEA_365+_FOOD_SV_25X17X9	10788	-2427	-13%	1	yes	im (lid 25)	4	2967	24%	28%
			IKEA_365+_FOOD_SV_25X17X6	5981			1	yes	im (lid 25)		1645		28%
			IKEA_365+_FOOD_SV_17X17X12	8782	-2222	-9%	1	yes	im (lid 17)		2394	25%	27%
	365 17x17	24470	IKEA_365+_FOOD_SV_17X17X6	13466			1	yes	im (lid 17)		3671		27%
			ANTLOP_HIGHCHAIR	6899	-	-	1	no	im		6081	-	88%
	OMSORG-Large	96500	OMSORG_SHOETREE_LARGE	53839	-42661	-44%	1	no	im	3	21910	23%	41%
	OMSORG-Small	105273	OMSORG_SHOETREE_SMALL	53839	-51434	-49%	1	no	im		7841	7%	15%
	Brada laptop support	12000	BRÁDA	12957	957	8%	1	no	im	1	10418	87%	80%
	Chostigt Ice Lilly Ice Maker	52800	CHOSIGT_ICE_LOLLY	55446	2646	5%	3	no	im/im/im	1	23696	45%	43%
	TRONES shoe cabinet	3439	TRONES_SHOE_CAB	3128	-311	-9%	2	no	im/im	1	3215	93%	103%
	Nordby Bed Tray 58x36	12000	NORDBY BED TRAY	18641	6641	55%	1	no	im	1	3901	33%	21%

8.6 Supplier F

F produces only one-shot items. Despite supplying to other customers other than IKEA it has machines completely dedicated to IKEA. At the time of the supplier visit each machine was dedicated to only one tool, but this was due to change in the immediate future following the arrival of new tools with the initiation of new product productions. Including these new products the total amount of Product Groups is 10. It is important to note that F does have excess machine capacity apart from the machines dedicated to IKEA that can be used if needed.

The production setup consists of all machines grouped by size placed next to a conveyor onto which the molded parts are fed. This conveyor transfers the parts to a labor station where they are manually placed on pallets. As one side of the conveyor is unobstructed it is possible to add similar labor stations here as to not congest the main station in the event of a high production level. Because of the simple nature of packing requiring no assembly F conjectures that factoring in labor in their capacity determination is insignificant as the availability of labor is high.

The capacities are currently calculated as the tooling capacity based on a 138 hour week. This takes planned downtime into account but not capacity losses due to breakdowns and defect rates.

Implementation

Due to the foreseeable introduction of new tools to be used in machines currently dedicated to other machines, the template was implemented to consider this. Despite the lack of ability to provide weekly raw material capacities the sharing of these Resource Groups incurred the linking of all but one Product Groups into one production system. Due to the lack of information regarding downtime within the 138 hour week and defect products rates of 2.5% and 2% respectively were set by supplier. The figures provided on cycle times of the packing Resource Groups is based on the approximate time it takes to finalize a pallet for shipment.

The results of the implementation at F are shown in the table below:

Table 6. Results of the implementation for the supplier F.

	Old group name in GPS	Old GPS capacity (pieces)	New Product Group name	New capacity (pieces)	Capacity difference		Bottleneck		No of PG sharing resources	Forecasted need (pieces)	Utilization		
					(pieces)	(%)	Amount	Shared			Type and specifier	Before	After
F	SÄMLA box 5l	41883	SÄMLA_5L	41295	-588	-1%	1	no	im	29100	69%	70%	
	SÄMLA box 11l	17729	SÄMLA_11L	16138	-1591	-9%	1	no	im	16042	90%	99%	
	SÄMLA lid 11l/22l	22909	SÄMLA_LID_FOR_BOX_11/22L	21586	-1323	-6%	1	no	im	24969	109%	116%	
	SÄMLA box 22l		SÄMLA_22L	8645	-	-	1	yes	im(28)	7883	-	91%	
	SÄMLA lid 5l		SÄMLA_LID_FOR_BOX_5L	42546	-	-	1	no	im	21952	-	52%	
	Trofäst small	18667	TROFAST_BOX_30	17589	-1078	-6%	1	no	im	5964	32%	34%	
	Trofäst medium	16800	TROFAST_BOX_23	5515	-11285	-67%	1	yes	im(28)	5029	30%	91%	
	Trofäst large	15273	TROFAST_BOX_36	14391	-882	-6%	1	no	im	2127	14%	15%	
	Trofäst lid	33107	TROFAST_LID_40x28	39574	6467	20%	1	no	im	16141	49%	41%	
	Antonius drawer 25l	13894	ANTONIUS_DRAWER_25L	12835	-1059	-8%	1	no	im	6658	48%	52%	

8.7 Supplier G

G is a 100% IKEA dedicated supplier. They produce 23 Product Groups of which approximately half are one-shot items and the other half consist of components that are packed together, therefore in essence assembled products. All machines except for an overmold machine and a blow-molding machine are laid out according to size feeding onto two parallel conveyor belts leading to shrinkwrap machines. Tools are allocated to machines of appropriate sizes based on experienced available capacity.

Implementation

The fact that many items consist of multiple molded components means that the complexity of machine sharing between Product Groups is high. This resulted in 15 Product Groups being connected to one production system. The results of the implementation at G are shown in the table below:

Table 7. Results of the implementation for the supplier G.

	Old group name in GPS	Old GPS capacity (pieces)	New Product Group name	New capacity (pieces)	Capacity difference		Bottleneck		No of PG sharing resources	Forecasted need (pieces)	Utilization		
					(pieces)	(%)	Amount	Shared			Type and specifier	Before	After
G	Jämka -Round lid	39120	JÄMKA_FOOD_SVR_0,3L	4133	-29644	-76%	1	yes	im(18)	3356	20%	81%	
			JÄMKA_FOOD_SVR_0,5L	5343			1	yes	im(18)	4339		81%	
	Jämka-4s	9240	JÄMKA_FOOD_SVR_W_LID_54	9736	496	5%	4	yes	im(16)/im(17)/im(18)/im(13,14,21)	7906	86%	81%	
			JÄMKA_FOOD_SVR_20x14x4	7791			2	yes	im(17)/im(13,14,21)	2990		38%	
	Jämka- Oblong lid	46200	JÄMKA_FOOD_SVR_20x14x6	21976	-4349	-9%	2	yes	im(16)/im(17)	9171	44%	42%	
			JÄMKA_FOOD_SVR_20x14x10	12084			3	yes	im(17)/im(13,14,21)/tool	7985		66%	
	Smask spoon	11904	SMASKA_SPOON	21850	9946	84%	1	yes	im(13,14,21)	5845	49%	27%	
	Smask plate	19840	SMASKA_PLATE	27317	7477	38%	1	no	tool	13130	66%	48%	
	Smask cutlery	15520	SMASKA_CUTLERY	9284	-6236	-40%	1	yes	om(12)	10006	64%	108%	
	Smask beaker	17131	SMASKA_BEAKER	10369	-6762	-39%	2	yes	om(12)/im(18)	11175	65%	108%	
	Smask bowl	16285	SMASKA_BOWL	25610	9325	57%	1	no	tool	10768	66%	42%	
	-		JÄMKA_JAR_WITH_LID_S2_1,1/1,9L	2748	-	-3	yes	im(15)/im(18)/im(13,14,21)	2231	-	81%		
	-		JÄMKA_JAR_WITH_LID_S2_2,5/3,5L	4881	-	-2	yes	im(18)/im(13,14,21)	3964	-	81%		
	-		JÄMKA_JUG_WITH_LID_1,7L	3729	-	-2	yes	im(15)/im(18)	3028	-	81%		
	GO	5676	GOMORGON_STOR_UT_S3	5310	-366	-6%	1	yes	im(15)	2414	43%	45%	
	Legitim White AP	20877	LEGITIM_CHOPPING_BRD	22598	1721	8%	1	no	im	14329	69%	63%	
	Legitim White												
	Legym	10831	LEGYM_SALAD_SERV	12336	1505	14%	1	yes	im(7)	5508	51%	45%	
	Vaken 25l	11317	VAKEN_GLAS_25CL	7939	-3378	-30%	1	yes	im(7)	3545	31%	45%	
	Vaken 50l	8398	VAKEN_GLAS_50CL	10643	2245	27%	1	no	im	2743	33%	26%	
	-		TOMMAT_SPRAY_BOTTLE	34676	-	-	1	no	im	51434	-	148%	
	-		IKEA_PS_VÄLLÖ_WATERS_CAN	20246	-	-	1	yes	im(6)	18054	-	89%	
	Prickig	29250	PRICKIG_MICRO_LID	21295	-7955	-27%	1	yes	im(6)	18989	65%	89%	

8.8 Supplier H

H is one of the two suppliers in Taiwan, and has eight Products Groups within their production. The production setups consist basically of injection machines, ultrasonic assembly, and packaging. The

production is shared with other customers, but the machines were mainly dedicated to IKEA within each Product Group. They currently calculated the capacities by looking at the bottleneck's weekly throughput. They if they had more than one product using the Resource Group the capacities are simply divided by two. The demand at the supplier was very low at the time of the supplier visit and they had built up huge stocks preparing for upcoming orders. Because of the low demand there is low utilization of the resources throughout the whole factory, which means that some machines are not in use.

Implementation

To give the capacity calculations more accurate figures all machines and tools at hand were registered, even if some were not in use. The template worked well, but there was low level of understanding on the first day because of low English skills, but the acceptable level of understanding was achieved at the end of the second day following discussions and explanations. The factory had many parts of the Products Groups being outsourced and the transports times are not considered because of high quantities in the transports. In the production there was two Product Groups that shared one common problem in the implementation of the current template. Within these two Product Groups the products had different colors and where produced in different ways. Some of the colors needed coating that resulted in a split of the Product Group. The Product Groups and capacities before and after the implementation are shown below in Table 8.

Table 8. Results of the implementation for the supplier H.

	Old group name in GPS	Old GPS capacity (pieces)	New Product Group name	New capacity (pieces)	Capacity difference		Bottleneck			No of PG sharing resources	Forecasted need (pieces)	Utilization		
					(pieces)	(%)	Amount	Shared	Type and specifier			Before	After	
H	RAFFIG hook	17280	RAFFIG (black&white)	70867	89672	519%	1	yes	pack(ra)	7	8983	52%	13%	
			RAFFIG (silver)	36085		1	yes	pack(ra)	4574					
	VASENTLIG	54000	VASENTLIG_FINIAL (white)	54526	13214	24%	1	yes	im(f2,f5,f6)		17409	32%	32%	
			VASENTLIG_FINIAL (silver&gold)	12688		1	yes	im(f2,f5,f6)	4051					
	SKULPTUR	15320	26139	11019	73%	2	yes	pack(ss)/tool	6671		44%	26%		
	SAREGEN	10584	4236	-6348	-60%	1	yes	pack(ss)	356		3%	8%		
	UTHALLIG	10400	8524	-1876	-18%	1	no	im	0		0%	0%		
	-	-	27000	-	-	1	no	pack	1		27044	-	100%	
	KVARTAL	13166	7765	-5401	-41%	1	no	im	1		12469	95%	161%	
	SYRLIG	43200	SYRLIG_CRITN_RING_25MM	18358		2	yes	sm(h)/sm(c)			2	793		
			SYRLIG_CRITN_RING_38MM	20850	-3983	-9%	2	yes	sm(h)/sm(c)			2	8855	18%

8.9 Supplier I

I is a supplier that has 11 Product Groups at their factory. The Product Groups basically follow these five steps; extrusion, cutting, printing, and packing. I has other customers besides IKEA, but there was a low amount of sharing of specific Resource Groups. The suppliers have a lot of Free Range products (seasonal products) that were not included in the template because of no demand during the supplier visit.

Implementation

The supplier had very high knowledge of English which made the implementation process very efficient. During the visit the template that was already filled out by the supplier was checked and reviewed

together. The template was filled out correctly and the visit was mainly used for checking the understanding and answering questions that came up. The supplier had spent two hours reading the template's instruction manuals, and that was enough to achieve the highest understanding of all suppliers during the process implementation. This shows that when having good English skills the template instructions can provide the suppliers with adequate knowledge to independently use it. In Table 9 shown below the Product Groups and capacities before and after the implementation are presented.

Table 9. Results of the implementation for the supplier I.

	Old group name in GPS	Old GPS capacity (pieces)	New Product Group name	New capacity (pieces)	Capacity difference		Bottleneck		No of PG sharing resources	Forecasted need (pieces)	Utilization			
					(pieces)	(%)	Amount	Shared			Type and specifier	Before	After	
I	LUUDA	62308	LUUDA_PLACE_MAT	300421	238113	382%	1	yes	em(1)	7	67000	108%	22%	
	OMTYCKT	62308	OMTYCKT_PLACEMAT	203201	140893	226%	1	yes	em(1)		45318	73%	22%	
	SADD	36000	SADD_PLACE_MAT	74066	38066	106%	1	yes	em(1)		16518	46%	22%	
	DROMMAR	15556	DRÖMMAR_CAKE_DOLLY	6641	-4004	-26%	2	yes	em(1)/pack(p2)		2306	15%	35%	
			DRÖMMAR_STENCIL	4911			2	yes	em(1)/pack(p2)		1705			
	KLISTRIG	79208	KLISTRIG_PLACEMAT	107454	28246	36%	2	yes	em(1)/pack(p2)		37312	47%	35%	
	SUMMERA drop file	7200	SUMMERA_DROP_FILE	10377	3177	44%	1	yes	em(1)		2314	32%	22%	
	ORDENTLIG	111467	ORDENTLIG_PLACEMAT	127656	16189	15%	1	no	sm		1	87361	78%	68%
	VANNERNA	3960	VANNERNA_DRAPE	2550	-1410	-36%	2	yes	sm(cm)/pack(v)		2	1112	28%	44%
	-	-	VITAMINER_DRAPE	1931	-	-	2	yes	sm(cm)/pack(v)		1	842	-	44%
	PATRULL	-	PATRULL	40000	-	-	1	no	comp		1	4595	-	11%

9 Analysis and Evaluation

In this chapter the empirical findings are coupled with the theoretical framework to analyze the OSCP process. The current working methods are first analyzed, followed by an analysis of the implementation of OSCP and especially its components Product Groups and Resource Groups. Finally the results are analyzed along with potential benefits to IKEA and its suppliers.

9.1 Current Working Methods

IKEA seems to have a close strategic relationship with all the suppliers visited. One evidence of this is that the tools used by the suppliers are owned by IKEA, who even support supplier development by for example aiding in machine investments. The ownership of the tools means that IKEA has insight into these capacities, but currently the rest of the production is not as transparent. The share of production turnover that IKEA products comprise justifies the close relationships for customers completely dedicated to IKEA or those with a high share. For those with lower shares the justification is less apparent. For all suppliers there is however a close communication that enables supply chain optimization by sharing information.

9.1.1 Suppliers

The suppliers' methods of calculating the capacities presented to IKEA are largely derived from the total tooling capacities based on the planned weekly working hours. This is because the aim in the production planning is that tools and the machines be the bottlenecks. However, they lack consideration of the tactical plan of tools to machines, which may constrain the capacity when machines share more than one tool. Other capacity losses due to breakdowns and defect rates are not properly considered. Some consider them by arbitrarily subtracting weekly production hours while others do not consider them at all. This means that the provided capacities are inconsistent and may have a tendency to be inflated.

The focus of this thesis is the method in which capacities are calculated, not the method in which the supplier plans capacities. The important aspect to consider is that they do have tactically planned allocation of tools to machines. Most suppliers seem have a non-systematic method of capacity planning based on experience, which questions the efficiency of these plans as is evident in the varying level of utilization in many functional productions. Regardless of this the utilizations of most resources at the suppliers are quite low, which means that suboptimal allocation plans may not impede the efficiency of the productions in the current state. There is however a disregard for the planning of labor resources. This means that the efficiency of the labor force cannot be evaluated.

9.1.2 IKEA

One of the key tasks of the local TA with regards to capacities is to register them. For this, the current grouping of articles is performed based on consultations with the suppliers, and the naming is decided by the responsible SP. The latter means that there is no standardized naming globally for IKEA. The duty of determining of the capacities is given to the supplier, which means that an understanding of how they are determined is lacking, preventing a proper evaluation of their accuracy and credibility. Evidence of this is the fact that the current capacities provided by the suppliers that are used operationally and tactically are not operational or tactical.

This relates to another key task for the TA, which is to maintain availability by ensuring that orders can be fulfilled. The tactical work is limited due to the experienced unreliability and volatility of the SPI. If the capacity figures are inflated leading to exceptions being missed and orders being cancelled, this can be a cause of fluctuations of the SPI. This means that SPs tend not to respond to exceptions until actual orders are in place and it is too late. Currently the only response to exceptions is to contact the supplier, and if there is no possibility meet the need capacity leveling is performed. This is an unstructured and time-consuming solution.

The strategic focus for IKEA's TAs with regards to capacity planning is tool investments. Without a clear picture of the rest of production, especially with regards to the machine inventory, tool investment decisions may be difficult.

9.2 OSCP Implementation

The key aspects of the implementation of OSCP are the effectiveness of the method in which it is implemented as well as the applicability of the process to the specifics of plastic production. The latter is especially important to analyze for the key concepts of Product Groups and Resource Groups.

9.2.1 Process Implementation

As previously explained the investigation of the initial state, in essence the setups of the various productions for which the process was to be implemented as well as the current means of determining and allocating production resource capacities, was essentially performed in conjunction with the implementation phase. The plan for implementation essentially comprised of the template for collecting and processing the data from production, and the fact that this was continuously updated at each implementation has led to a slightly different practice being implemented. This makes the implementation ineffective as it means that the first suppliers need to be presented with the final version as opposed to the version they were initially presented with. This presents a notion of unpreparedness from IKEA's side and may lead to a lack of faith in the process from the suppliers.

What the planning part of implementation lacked was a clear idea of benefits to the suppliers, and as a result none were presented. Although many evidently realized the benefits as a tool to aid in production planning, more emphasis should have been placed on presenting this. Without a clear picture of the benefits to the supplier they may lack incentive to maintain the template and update it regarding changes in the production setup.

Another evident hurdle is the distribution of a template with instructions in a language of which the recipient is not fluent. Many of the answers to the questions raised during the visits were in the instructions and the fact that they were raised therefore questions the extent to which the suppliers were prepared. This preparation was meant to be a key part of the plan for the implementation of the process but failed, meaning that valuable time was spent clarifying issues dealt with in the instructions.

The directive from IKEA to implement the OSCP method of determining capacities at 9 suppliers and the time limit in which to do it presented an obstacle in evaluating the implementation process. After each implementation at a new supplier the ability in which the supplier can use and update the template should be thoroughly evaluated. This would have the potential to improve the method if implementation, especially the instructions for using the template as well as the user-friendliness of it.

9.2.2 Product Groups

The implementation of the process of Product Groups as defined by IoS seems successful. The groupings differ very little from the way that articles are currently grouped as it is based on the same logic being the group-specific tools. The standardized naming of the Product Groups according to OSCP is generally more specific than the previous names registered in GPS. For many groups the name is currently only the family name of the product. The SPs responsible for the suppliers are aware of the specific product that the family name refers to, but for IoS it means that they have to look at the specific articles within the group to determine which specific product it is. One issue is the use of the letters Å, Ä, and Ö in the new names. They were rarely used prior to the implementation and may be due to the unnecessary added complexity in the writing them as most employees have no keys for these on their computers. Substituting these for A and O should not present a complication as the risk of this leading to a common name for different Product Groups seems unlikely.

Looking at the exceptions where the articles differ within a group they are often based on color and labeling, as well as the assembly difference in some instances such as for the Antilop Highchair. These differences generally seem to consume minute differences in resources in terms of raw materials and labor hours. They can therefore most often be disregarded. One instance where the calculated capacity may not be able to be reached is when product sets containing articles of different colors are produced. In the example from G the three different colored Smaska Bowls are produced in three different machines in

parallel, but it is assumed in the capacity calculation that this practice does not need to be followed. This means that if need be they could theoretically produce the different colors in one machine in sequence changing color after each batch, but this may not be practical and the effect that color changes have with regards to reduced capacity are not properly taken into consideration.

Where the color difference is dependent on a coating step this can be a bottleneck. It should be analyzed whether or not this is a possibility, and if it the proposed Product Group should be split up into those articles that require coating and those that do not. For the products Raffig and Väsentlig produced at H the coating capacity is lower than the determined bottleneck capacity. This means that if the allocation were to change to extremes, if the coated products had much higher demands, coating would become the bottlenecks given the current capacity. As this step is outsourced and the capacity is based on what the sub supplier can promise based on forecasted need, and since the need is currently low, an important question is whether the sub supplier can in fact provide a higher capacity. For the sake of transparency however it is recommended that the group is split.

In four instances the Product Groups have been divided up from their old grouping. The Jämka series of food containers using the same lid have been grouped at the supplier G and the 365+ series of food containers have also been grouped based on identical lids. On both occasions the lid has previously been identified as a bottleneck and as such the grouping can only be seen as viable if the products belong to a Situation 2. This is the case for the 365+ food containers as they share only the lid machine and each has a dedicated box machine. Investigating the figures it becomes evident also that when determining the capacity for each new Product Group with total allocation of the lid machine this machine remains the bottleneck. The problem lies in how to account for the use of different box machines and tools for the aggregated group.

In the case of the Jämka food containers they belong to a production system with very complex sharing (see Appendix G) making it less viable to aggregate the different products into one group. The machines that make the product specific boxes is shared with other Product Groups for which these machines are the bottlenecks, meaning that their allocation to the Jämka food containers is critical in acquiring a view of the total capacity of the production system. Without even looking at the sharing of the machines making the boxes the tooling capacity of each of the round Jämka boxes is less than the capacity of the lids, meaning that in cases of extreme allocation of the time in the lid machine the bottleneck will shift (Figure 24).

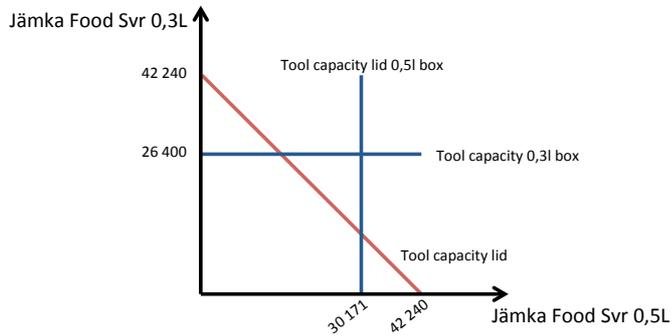


Figure 24. Looking at the tooling capacities of the round Jämka food savers.

Regardless of the complexities of the production setups to which these aggregated groups belong there is still a problem if the bottleneck is expanded to increase the capacity. Without the overview of the machines used for the specific boxes the ability to determine whether these become the bottleneck would be lost.

From this it can be concluded that the directive in OSCP of grouping products using similar Resource Groups is essential as deviating from this creates complications. The disaggregation of the current Product Groups based on differences in color and labeling is unnecessary as the differences in consumption of Resource Groups are insignificant. Therefore the decision to base the Product Groups on the tools used in their production seems suitable.

9.2.3 Resource Groups

The generic Resource Group names on the most part cover the types of production resources used in injection molding plastic production. One supplier visited does however not produce injection-molded products, but rather silicone products and hence the predetermined generic names do not apply. The analysis of the grouping is however divided into the different generic groups.

9.2.3.1 Raw materials and components

When looking at raw materials and components it is unreasonable to group them with each other or any other production resources. They can be grouped as a Type II group (see chapter 7.2.2.1), but this results only in complication due to the need to manually determine which is a bottleneck in the Type II group, and a lack of overview. There are no foreseeable benefits other than minimally reducing the amount of information presented in the consumption table.

As the supplier orders raw materials and components from sub-suppliers based on the forecasted need, and they have never experienced this as a bottleneck, the relevance of determining the weekly capacities

for these resources is questionable. One rare exception where raw material might constrain the capacity is when there is an extreme deviation in the total demand for all products using a certain material at a supplier. This deviation would need to incur an increased need of the material exceeding 20% of the forecasted need as well as any buffer stock. Component sub-suppliers could be asked for maximum weekly capacity figures or the weekly capacity can simply be deduced from past proven capacity.

Overall it can be viewed that disregarding these Resource Groups' capacities only results in a slight and acceptable depreciation of the accuracy of the Product Group capacities. Including them in the template and maintaining them seems therefore only beneficial to the supplier.

9.2.3.2 Injection machines

The grouping of injection machines is only necessary when more than one is used to perform the same task for a certain Product Group. This is because OSCP assumes that a Product Group does or does not use a Resource Group. If two resources perform the same task and were to constitute two separate Resource Groups it would mean that a Product Group may or may not use one depending on whether it uses the other, which is not possible. This necessity to group in some instances therefore results in grouping of machines of different sizes if different tools contributing the same pieces require it, often resulting in a need for a weighted average consumption rate if the cycle times or number of cavities differ for the tools. The weighting has been based on the nominal capacity of each machine based on the tool used. This may inevitably affect the accuracy of the calculated capacity, especially as a result of complex sharing of Resource Groups

Line production

The line productions investigated provide few complications with regards to grouping of resources. As this method of production is intended for high volume low diversity production there is inherently little sharing. There are essentially two forms of line production witnessed at suppliers, one is where complex assemblies with support machines result in a need for production to be specialized and dedicated to a Product Group and one where the production is interpreted as line as a result of the choice to dedicate resources to products. Due to the fact that most products are one-shot and when assembly is required it most often entails unskilled manual labor, there is always a potential flexibility in where tools are used. In the example of the line production of the Tolsby Frame at the supplier B, there is a sharing of one injection machine with the product Fantastisk despite the specialization of the production line. The conclusion is that despite interpreting line productions as dedicated to Product Groups the fact that the tools in machines can be changed rather easily there is always the potential to deviate from this dedication.

Functional grouping

The natural way of grouping injection machines functionally is by size. This is due to the flexible nature of the machines in that many different tools can be used in them. For this many suppliers plan the layout of their production functionally, especially for the production of one-shot items, and therefore a potential basis for grouping resources. The visited suppliers do however already have a plan for the use of tools in machines. Grouping machines by size would mean the resulting capacities would depend on the tools being able to be used on all machines of a certain size. This could challenge and improve their planned dedication but also might not be feasible due to other factors. It might also result in instances where a Product Group using different machine sizes for the same parts results in a need to aggregate these size groups.

When attempting to implement this form of grouping at G which has a layout based on sizes these complications arise. As shown in the reference case (see Appendix G) there is a grouping of machines number 13, 14, and 21 due to the fact that the Smaska Spoon is manufactured in all three. The sizes are however 140T, 140T and 260T respectively. This means that a group based on sizing would also include all machines within this interval. Because tools have a required minimum clamping force it means that tools requiring a force at the upper end of the size interval for a group cannot be restricted to the proper sized machines but are assumed to be able to use all machines in the group.

Table 10. List of machine numbers and sizes at G.

Machine Number	Size
1	520T
2	450T
3	450T
4	250T
5	560T
6	450T
7	250T
8	300T
9	250T
10	200T
11	200T
12	75T
13	140T
14	140T
15	320T
16	260T
17	320T
18	220T
19	260T
20	320T
21	260T
22	600T

Partial Resource Group sharing

A problem that arises regardless of how the grouping is performed is stems from when one Product Group requires several machines to be grouped into a Resource Group but one or more other Product Groups use only specific machines in that group. This is the case for the “IM #13/#14/#21” Resource Group where only the Jämka Spoon uses all machines but the four other Product Groups do not as shown in Table 11.

Table 11. Product Groups using Resource Group "IM #13/#14/#21" at G and the specific machines they use.

Product Groups	Machine
SMASKA_SPOON	13, 14, and 21
JÄMKA_FOOD_SVR_W_LID_S4	13
JÄMKA_FOOD_SVR_20X14X4	13
JÄMKA_FOOD_SVR_20X14X10	14
JÄMKA_JAR_WITH_LID_S2_1,1/1,9L	13
JÄMKA_JAR_WITH_LID_S2_2,5/3,5L	13

One solution could be to alter the constraining Resource Group based on the tooling capacity of each Jämka series product that uses this group to instead comprise of two constraining Resource Groups for machines 13 and 14 respectively. The tooling capacity constraint could remain but as constraining to one machine will impose the same restriction it is extraneous. If we complicate the example further by allowing the Jämka Food Saver with lid to also use injection machine 14 this would incur a necessity to have two additional constraining Resource Groups; “IM #13/#14” and a tool group for that specific Product Group. This example is shown in Figure 25 below.

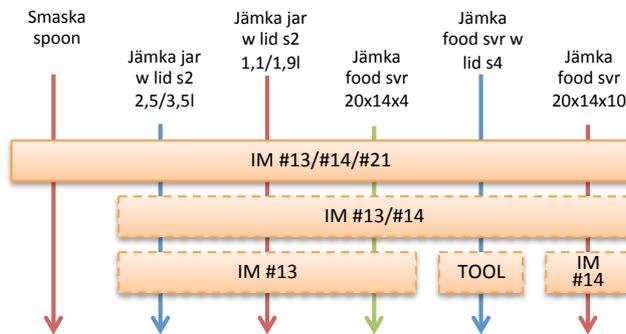


Figure 25. Example of complicated use of constraining Resource Groups due to the dedication of certain machines within a Resource Group.

This complexity would result in a difficulty in implementing the template and updating it following changes in tool to machine dedications. It also contributes to a source of reduced accuracy in the capacities if a consumption rate in the aggregated Resource Group is weighted. Consider if the Smaska

spoon's use of the Resource Group constitutes a weighted average consumption rate with high throughputs in machines 13 and 14 and low throughput in machine 21. As much of the machine time in these two machines will be allocated to the Jämka products, it can be assumed that machine 21 will constitute the majority of the production of the spoon. The resulting capacity would be inflated as this machine assumes a higher throughput than the reality. Though this is not the case in this example as the three tools used for the Smaska spoon are identical, it is the case for the sharing of the "IM Base" Resource Group between Tolsby and Fantastisk (see section 4.6 Production Scenarios). In this case one of the machines that is not shared with Fantastisk has a higher throughput than the shared one, meaning that actual consumption rate on the machine hours in the Resource Group allocated to Tolsby should be lower than the weighted average. The conclusion is that all average consumption rates in shared Resource Groups provide a source of error in the capacity of the Product Group for which the average is made, to a degree that is relative to the amount of machine time that is allocated away from that Product Group.

9.2.3.3 Support Machines

Support machines include machines used mainly in the production of technical plastic products that are not injection machines. They include for example bristling machines used for production of brushes and overmold machines. As they tend to be Product Group specific there no complications arise when implementing the process as a result of need for allocation. They do however sometimes require skilled labor to operate as is with the bristling machines at A. This labor may constitute a constraint if the current utilization of the machines is low resulting in a labor capacity prevents the ability to use all machines. The operational capacity must therefore take this into account.

9.2.3.4 Assembly and Packing

Assembly and Packing Resource Groups comprise of all final steps of production following the injection machine and eventual support machine Resource Groups. For assembly and non-assembly Product Groups these steps are grouped as a Type II Resource Group and named assembly and packing respectively. As previously mentioned the access to labor is abundant in China resulting in a lack of regard at suppliers for this resource in determining capacities. Many of the assembly and packing jobs are menial tasks such as moving product from assembly lines to pallets or placing labels on products. These "unskilled" labor resources can therefore on many occasions be disregarded in the calculation as the capacity of them can easily be expanded. The complexity of mapping the number of these laborers and determining cycle times for their contributions to different Product Group is a burden that should not be forced on the supplier unless needed. Skilled labor on the other hand presents an operational constraint due to the necessity of either finding appropriate people or training which takes time, and this labor force should be mapped and approximate cycle times should be determined.

On some occasions these two Resource Groups may include a machine such as the stamping machine used to assemble the Tolsby Frame at B or shrinkwrap machines used to pack many products. These are often disregarded, but as they have the potential to constrain the capacity of products requiring them they need consideration. At G, for example, many products are packed using the same shrinkwrap machines and the capacity of this should be determined using an empirically determined cycle time.

9.3 OSCP Evaluation

In order to evaluate the contribution of the OSCP process both the calculated capacities and the benefits to IKEA and its suppliers capacity planning are analyzed. The latter is not a goal for the press but seen as a vital goal for creating an incentive for the supplier to maintain the template seen as critical to the process.

9.3.1 Supplier Capacities

There are several factors that can be identified as critical to the proper calculation of the capacities at IKEA's suppliers and need to be analyzed in order to determine the accuracy of the resulting figures:

- The nominal weekly capacity in terms of production hours.
- The loss of capacity due to irregular downtimes.
- The dedication of the weekly capacity to IKEA.
- The loss of capacity due to defect products.

When implementing the OSCP process through the use of the template the figures gathered for the weekly capacities were figures given by the suppliers. As many remove hours each week to account for unplanned or irregular capacity losses, the given figures given may contain errors affecting the accuracy of the calculated capacities. All the weekly nominal capacities should be reviewed to ensure they are correct.

For an efficient use of the template it is recommended that the weekly production hours should be a variation of the nominal capacity only taking into account the regular planned downtimes. Even though for example tool changes and color changes constitute planned downtimes they are irregular in that they affect only some machines in production and happen at irregular time intervals and result in irregular durations of downtime. Data on all irregular production stops should be maintained and inserted in the template as downtime. This results in a simpler maintenance of the template as only one figure is updated.

In order to insure a higher degree of accuracy IKEA must make an effort to encourage the suppliers to thoroughly appreciate the value of having accurate figures. Their use of the template as a capacity planning tool should incentivize them to do so. Figures for downtimes due to the different factors including breakdowns and different irregular planned downtime should be maintained along with consumption rates, and could benefit the suppliers in analyzing their productions and implement changes to improve.

These figures may also be beneficial to IKEA in evaluating their suppliers by benchmarking them against each other. The realization of this may however remove suppliers' incentives to provide IKEA with accurate figures as they may chose to embellish them.

One cause for inaccuracy that arises from the downtime rates in the template is when they are administered to a grouping of machines. This means that a weighted average has to be calculated, which may not reflect the true capacity lost when the use of grouped machines is uneven. This average may also mean a time consuming job in updating the figures that could be avoided if they are taken into consideration in the calculation tools and automatically calculated.

Finally the dedication of weekly capacity to IKEA when production resources are shared with other customers presents a problem in the validity of the capacity figures with the method currently used. This is because there is currently no directive in place for this dedication, and when B was asked to perform it they used the template as a RCCP tool and only dedicated the amount of capacity necessary to cover the average forecasted need in the SPI. Many TA employees in Shenzhen as well as the suppliers visited experience large deviations in actual orders relative to the forecast in the SPI. This means that fluctuations of orders above this average will cause alarms and necessitate a high amount of work from IKEA's supply planners to insure that these orders can be fulfilled.

The goal for the future is for IKEA to be involved with the tactical dedication of suppliers Resource Groups. IKEA should then also be aware of the total net capacity of these suppliers out of a tactical and strategic perspective.

The defect rates has only a slight effect on the capacities as they tend to be very low, and the question is whether the burden of maintaining these figures for the sake of calculating capacities outweighs the importance of the slight inaccuracy. The defect rate can however provide the supplier as well as IKEA with information regarding the efficiency of the production with a potential for IKEA to benchmark this and support the improvement for those suppliers with problems.

9.3.1.1 The resulting capacities

It is difficult to perform a proper analysis of the resulting capacities calculated and allocated with the use of the template. This is because there is no follow-up of the figures. The capacities are in also most instances dynamic due to the frequent allocation of Resource Groups' capacities between Product Groups as a result of flexible productions, and dedications to IKEA. Figure 26 depicts how the dedication of a bottleneck Resource Group's capacity to IKEA and allocation of the dedicated capacity between Product Groups make the resulting capacities dynamic, as opposed to static capacities depicted in Figure 27 where the entire capacity of the bottleneck Resource Group is dedicated to IKEA and only used by one Product Group.

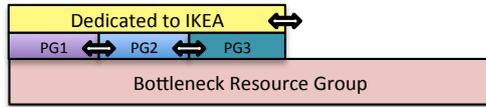


Figure 26. Dynamic Capacities.



Figure 27. Static Capacities.

Because of the very similar grouping of articles before and after OSCP implementation it is possible to compare them. When analyzing the difference of the capacities currently in GPS and those calculated by the template following the OSCP process with regards to if they are static or dynamic it shows a clearer picture of the impact of the change. It should also be pointed out that the lack of a standard way of working with regards to maintaining the figures currently in GPS means that some figures are set for long time periods and infrequently updated. This means that their relevance in the operational perspective is sometimes questionable.

Figure 28 and Figure 29 depict the distribution of percentual change of capacities $\left(\frac{\text{new capacities} - \text{old capacities}}{\text{old capacities}}\right)$ in 5 percent intervals for static and dynamic capacities respectively.

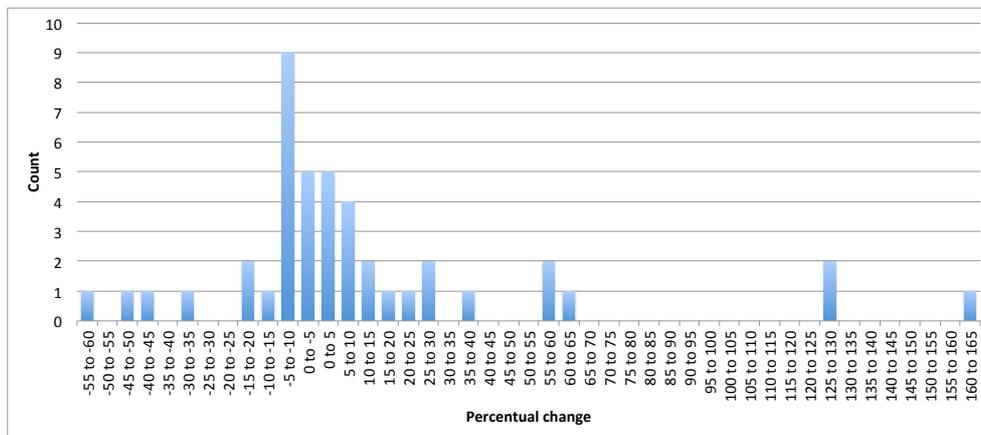


Figure 28. Distribution for the percentual change of capacity for products with static capacities (i.e. dedicated bottlenecks and dedicated productions).

Static capacities imply that there is no sharing of the bottleneck and hence no allocation of its capacity relative to the forecasted need, as well as no sharing of the production capacity with customers other than IKEA (Figure 28). 43 Product Groups have static capacities. As shown in the figure the new capacities are generally quite similar to the old. This is because the bottleneck is generally the injection machines, something that the suppliers were aware of before the implementation. The differences may be a result of how they handle the various capacity losses due to for example downtime and defect rates. The interval between 0% and -10% contain a lot of Product Groups, which may reflect a lack of consideration for this, while the Product Groups between 0% and 30% may be a result of arbitrarily reducing the capacity figures to consider this.

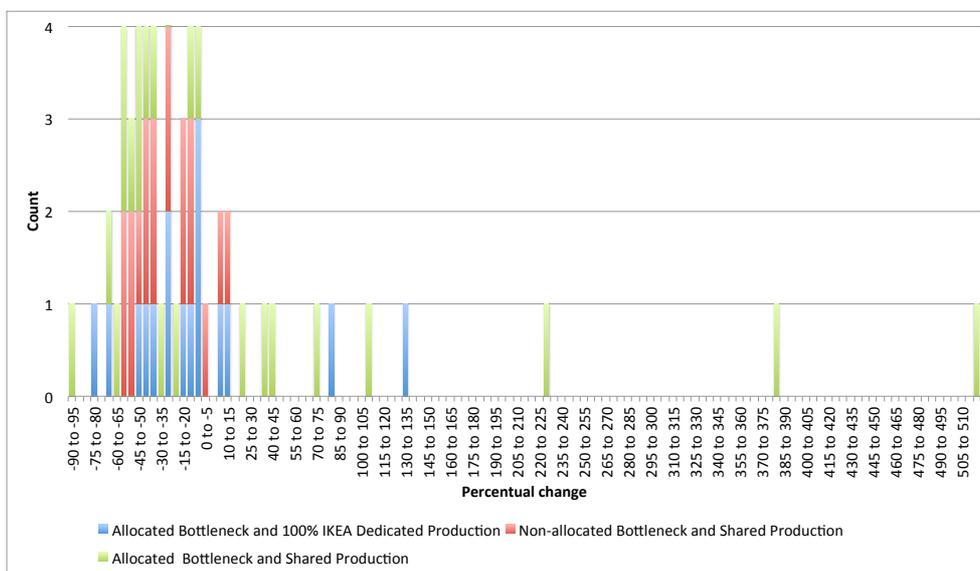


Figure 29. Distribution for the percentual change of capacity for products with dynamic capacities.

There are 59 Product Groups investigated with dynamic capacities. The new capacities for the products with dynamic capacities deviate more greatly than those from the static capacities as depicted in Figure 29. This is understandable as prior to the OSCP implementation the allocations of machine hours between tools used in those machines has generally been lacking and IKEA dedications that have been performed different between suppliers both before and after implementation. Some examples are B's previous lack of resource allocation and IKEA dedication, which means that their figures have been higher than the reality, while I's figures have been lower than the reality due to their dedication to cover the forecasted need plus 30%.

There are extreme differences between the new and old capacities that may be a result of factors such as

mistakes in the capacity calculation or simply changes in capacity due to investments in resources. The suppliers should go through these to insure that they are not a result of mistakes in the new capacity calculations. Overall the trend seems to be that the newly determined capacities are slightly lower than those previously registered, mostly due to the previous lack of allocation and questionable dedication of critical production resources, but also due to the handling of unplanned capacity losses. If these new figures are indeed more accurate than the old it means that the capacities were previously inflated which could lead to availability problems when there is high utilization. This is one of the key goals that OSCP aims to prevent.

9.3.1.2 Framework for evaluating capacities

The components defined in the OSCP process in (see chapter 4.3 Method of evaluating capacity) provide a good basis for evaluating the registered capacities. When the exception of demonstrated need (issued orders) is higher than the demonstrated capacity (notified deliveries) it suggests that there could be capacity constraints. It should however be noted that the demonstrated capacity is based on notified deliveries and failures to meet the demonstrated need may be a result of other factors than suppliers capacities. In these situations the demonstrated capacity should be checked against the planned capacity. For dynamic capacities resulting from bottleneck sharing this would provide little insight into possible errors in the registered capacities. Therefore the demonstrated capacity for all Product Groups that share Resource Groups with the Product Group for which there is an exception should be used in the template to determine the utilization of the bottlenecks. If the bottleneck utilization is under 100% there is a possibility that the figures are wrong, but as other factors may affect the demonstrated need this needs to be properly investigated before the registered capacities are changed.

9.3.2 Capacity Planning

The OSCP process is intended as a tool to aid IKEA in planning capacity. It aims to provide IoS with a more accurate picture of global capacities by providing local TAs with a tool to operationally and tactically assess the capacities of their suppliers. As previously discussed in the initial analysis (section 0), OSCP should also provide suppliers with a benefit from implementing it in order to incentivize them to maintain it.

The focus for the implementation has been to initially acquire good figures for operational capacities to support this level of planning, but the aim for OSCP is to provide a framework for tactical planning as well. When decisions are made within a certain planning horizon are made, they are restricted by the decisions made on the level before that. Since the key focus in the thesis has been the development of the template based on the OSCP framework its effect on the capacity planning is analyzed, as depicted in Figure 30. The templates provide a basis for the next level of capacity planning and can also be used to evaluate the previous level.

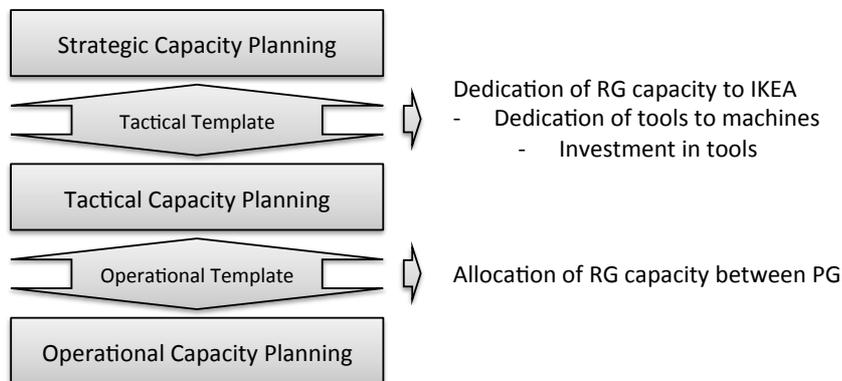


Figure 30. The roles of the templates in the capacity planning.

9.3.2.1 Operational perspective

Trading Area

One benefit for IKEA is the increase in insight into the capacities at suppliers that the OSCCP process provides. The key operational work performed by the TAs with regards to capacities is to insure that the need can be met. Currently if the need exceeds the registered capacity the SPs contact the supplier to see whether they have the possibility to increase the capacity. The supplier capacity value name created for OSCCP seeks to support this by providing information about what constrains the capacity. Following the ideas of TOC by identifying the system bottlenecks and focusing the production on these enables quick identification of the problems that need to be solved when the registered capacity is exceeded by the need. The Resource Group name provides the ability to see whether reallocation of the capacity in the constraint is possible. For this there is no need to contact the supplier as the reallocation can be tested in the template. The SP can search for all Product Groups with a matching Resource Group name and if this bottleneck is underutilized for some the capacity should be able to be transferred. The bottleneck type indicates whether there is a possibility to temporarily increase capacity. Operationally this is especially true for labor bottlenecks in the visited productions. It is also if injection machines are the bottlenecks as the flexibility of using tools in different machines means that there may be machines not dedicated to tools where they can be temporarily used. For this there is a need to contact the supplier.

This supplier capacity value name however lacks the ability to handle cases where there are multiple or moving bottlenecks. Currently the bottleneck type is not maintained in the template, but if it were added then all the relevant information for operational capacity planning would be maintained there. Therefore the supplier capacity value name should perhaps provide information to easily locate the template file instead. As explained in section 9.3.1.1, the nature of capacities being static or dynamic affects the

validity of the registered capacity value. If the capacity is static then the relevant information is the bottleneck type and whether it can be temporarily increased. If the dynamic nature stems for bottleneck sharing the investigation into whether the capacities can be increased by reallocation requires only access to the template, but if it stems from a dedication of capacity to IKEA it requires contact with the supplier to determine whether there is available undedicated capacity. The relevance of this information means that it could also be added to the supplier capacity value name.

One thing the allocation in the template does not take into account in its current form is the fluctuations of the weekly need relative to the average need. The allocation needs to be fixed in GPS for the time periods between events when the figures are updated in the system. If a Product Group fluctuates heavily and the bottleneck utilization given average need is relatively high, the result would be a large amount of warnings in GPS when the need peaks. When the bottleneck capacity is allocated it could lead to an unnecessarily high workload if the other Product Groups sharing this bottleneck fluctuate less and their allocated margin is less often utilized. Therefore the weighting of the allocation should perhaps take into account the fluctuations by calculating the standard deviation of the need over the 17 week time period and adding it to the forecasted need. Another way of reducing the fluctuations is to operationally look at a shorter time period. This would however mean that the frequency of updating the figures would have to increase which in turn means a higher workload.

Suppliers

The operational benefit to the supplier is the ability to perform an MRP based on the Resource Groups for as components and raw materials. As the template is designed as a RCCP the key benefits are mostly tactical. It supports their production planning by providing a picture of the resources necessary to meet the forecasted need.

Most of the suppliers have a planned dedication of injection machines to tools but many tools can be used in more machines than stated in this plan. Because the machines are often the bottleneck there is the possibility to move the tools to machines with forecasted low utilization to meet a demand that is higher than the registered capacity, given the utilization of non-bottleneck resources are not exceeded. In these situations the bottleneck name and identification code could be helpful in signaling this possibility. As the template gives an overview of the utilization of all Resource Groups this provides for a quick and easy support in determining where to move the tool. This short-term solution for exceptions is however in essence operational as it deals with alterations in the short term planning. A tactical decision would be to alter the plan for where tools are used. This would follow the TOC steps of especially identifying and elevating the bottleneck tactically to match the demand. This would entail a rework of data in the template, which supports the notion that IKEA should ensure adequate training for suppliers in this.

Where the OSCP process may impede the capacity planning ability of the template is with regards to grouping of resources where it is not necessary, such as Type II Resource Groups including most assembly and packing lines. This removes the insight into the capacity requirements from some resources, especially labor, which could be useful. An overview of all labor stations and proper information about throughput in these would provide a framework for tactically planning the hiring and firing of labor, a decision that seems to currently be based on experience and feeling.

9.3.2.2 Tactical perspective

Trading Areas and suppliers

The nature of the close relationship between the TAs and its suppliers means that the tactical perspective for both can be analyzed together.

The nature of the flexibility in which machines to use tools, especially in functionally grouped layouts, means that the use of the template to support tactical decisions would entail a rework of it from its current operational form. The supplier's planned dedications of tools to machines should not be taken into consideration, instead the machines should be grouped by size and tools should be allocated to proper groups. This would show the total machine hours capacity for all the tools as well as the total tooling capacity. In this tactical version of the template there is no necessity to include labor and raw materials, as these are not affected by strategic decisions. A template such as this would also support the tactical machine dedication plan by allowing a greater overview over different possibilities of where to use tools. If this promotes a better tactical plan then it would incur saving through a more efficient production at the supplier.

The dedication of capacity to IKEA being performed in cooperation between the supplier and BD, as well as the insight into the capacities, should improve IKEAs availability of products. This is by being able to hold the supplier accountable to exceptions where the need is not met despite a less than 100% utilization of IKEA dedicated resources.

The tactical perspective for IKEA also deals with the investments in tools, which are always owned by IKEA, and injection machines, which IKEA often supports. The OSCP process of identifying and maintaining information pertaining to the bottlenecks of productions supports a TOC based management to support the strategic decision-making.

10 Conclusions and Recommendations

10.1 Conclusions

The purpose of this thesis has been to implement and evaluate the OSCP process for working with capacities. It also includes a mapping of the current methods of doing this to provide a basis for the evaluation.

The current method of working with capacities leads to several problems. The groupings prior to OSCP are generally the same as the IoS defined Product Groups with few exceptions. With regards to the determining of capacities the general practice is to look at the total tooling capacity based on the nominal production hours, sometimes minimizing these to buffer against any unplanned events or issues. The former means that there is no allocation of hours in shared injection machines to the tools used in them. The latter means that the accuracy of the figures is questionable. When registering capacities the current naming of product groups is decided by the SP responsible for the supplier, which has led to names being unstandardized and on many occasion only product family names. This makes the task of aggregating global capacities difficult.

The key focus of the thesis has been the actual implementation of the process to calculate the operational capacities. The preparation for the implementation was lacking in that the specifics of plastic production were not investigated prior to the implementation, but rather during the implementation, and the methods described in the OSCP material for determining the capacities was below par and lacked tools to support it. The latter lead to the development of a comprehensive template to aid in the implementation process and the former meant that this template needed much revision following new complications arising at successive supplier visits.

Once the final template was developed the implementation process was more effective as it could be applied to all the investigated productions. The addition of a table of needs presented in the template also allows for a RCCP tool that is a very useful for the suppliers in planning their production. This is seen as an important factor in incentivizing them to maintain and update the template following changes in production, and input values such as the forecasted SPI need, consumption rates, and downtime and defect rates. This ensures the continuous accuracy of the figures.

When implementing the process the grouping of production resources into Resource Groups was limited to grouping injection machines, and assembly and packing lines. The injection machines were only grouped when necessary, which was a result of them contributing the same piece to a product. Since the focus for the implementation was to acquire operational capacity figures the dedication of tools to

machines was based on the suppliers' tactical plans. There is however a flexibility in using different tools in different machines which means that the tactical or strategic capacity figures can be based on grouping machines functionally by size. There were some flexible productions that presented very difficult implementations of the template that limit the accuracy of the capacities calculated as well as present problems for maintaining and updating the template.

The results of the OSCP process are divided into quantitative and qualitative results. The quantitative results are the new capacities that have been calculated. Although it is difficult to evaluate them, as they cannot be followed up due to the time constraint, the difference between the new and old figures was investigated in section 9.3.1.1. When looking at static capacities, i.e. Product Groups that do not share bottlenecks with other Product Groups or other customers, the deviation from the old figures was rather small. The dynamic capacities, i.e. where bottleneck capacities are allocated between Product Groups or shared with other customers or both, the new figures were generally lower. This is mainly due to the previously lacking practice of allocating and dedicating injection machine hours between Product Groups and to IKEA respectively, as well as the lack of proper consideration of unplanned losses in capacity.

The qualitative results deal with the way the process can help both IKEA and its suppliers with their capacity planning. The benefits are summarized in the following points for IKEA and suppliers respectively:

IKEA

- It allows IKEA to verify suppliers' capacities.
- OSCP provides a greater insight into the factors that affect capacities.
 - This enables a better handling of complications arising when the need exceeds the capacity both operationally and tactically.
 - Allows for the possibility to benchmark suppliers against each other to find areas of improvement and evaluate their efficiency.
 - Potential to influence IKEA dedication of specific resources and allocation of capacity in these resources to specific products.
- It provides a standardized product grouping and naming that enables a better global overview.

Suppliers

- The key benefit to the suppliers is the tool that the template provides.
 - It can be used as a RCCP tool for the allocation of machine hours to products.
 - It has the potential to aid in the planning of labor if consumption rates and weekly capacities for this are properly maintained.

- It provides a CRP to determine need for raw materials and components.
- The implementation has provided the suppliers with an awareness of the impact of unplanned or irregular capacity losses and how to handle these.

10.2 Recommendations

With regards to calculating the capacities there are some issues that need to be addressed. In order to insure the accuracy of the capacity figures IKEA should ensure that the suppliers maintain information about breakdowns and defect rates correctly, something that is not experienced today. The allocation basis should also be reviewed and standardized, perhaps taking into account standard deviation or also other factors such as service level goals. The allocation should also be reviewed more frequently than the recommended 3 times a year for some product such as seasonal products and volatile products where the need fluctuates greatly.

IKEA should review the implementation process for the OSCP process. First of all the template that was developed in this thesis could be used for other suppliers, but it is recommended that it is first properly tested and evaluated in different productions and over a period of time to see if improvements can be made. The goal for the process is “one common way of working”, which means that only one template should be developed. In order for the suppliers to maintain it they should be properly educated and properly incentivized. The former means that firstly the instructions should be translated to the local language where the English skills are below par. It could also mean workshops to train in the use of the template. To support suppliers continuously in updating the template following changes in production a “super user” should also be trained at each Trading Area, and they should in turn be supported by an expert at IoS. The benefits to the suppliers must also be focused on, as the lack of this may prevent an implementation. The authors chose to present the rough-cut capacity plan in the template to be used by the suppliers.

In this thesis the focus for the implementation of the OSCP process was to determine the operational capacities. In order to determine the tactical capacities a framework for this must be set. This must address the difficulty of the flexibility in plastic production with the ability to use a certain tool in a wide range of machine sizes. The total tooling capacity should be linked to the total machine capacity in some way to provide a good overview that enables a good potential to dedicate machines to tools and machine time to IKEA. Apart from the injection machines and tools the tactical capacities should look at other machines only, and not raw materials and labor. The lead time to increase labor, both skilled and unskilled, can be assumed to lie within the time frame for tactical planning.

One problem with OSCP that needs to be addressed is the Supplier Capacity Value Name. The authors' recommendation is to review the importance of maintaining the bottleneck name and bottleneck type in

this way. The potential for multiple and moving bottlenecks as has been experienced with the operational capacities complicates the implementation of this naming. Instead the name could include an identification code for the template, which itself should be stored in a standardized way so that it can be accessed easily. This is because the template provides all the detailed information with regards to what affects the capacities. Including an identifier as to the static or dynamic nature of the capacity can be used operationally along with the template code to aid in the decision making when working capacities on a daily basis (as explained in section 9.3.2.1).

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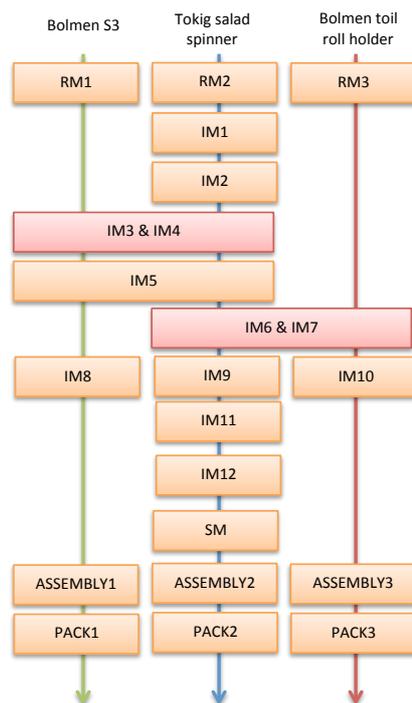
Appendix A – Reference case A

Case description

Three Product Groups share a single or a number of Resource Groups together. The production setup contains of a number of injection molding machines producing parts that is assembled together to the end product. What makes this production setup a little bit more complicated than other production setups is that there are dissimilar parts within a Product Group produced in the same machine with only a tool-change in between. Additional to that there are also other Product Groups sharing that machine. These means that the sharing is rather complex for this small amount of Product Groups.

Production setup

In the Figure below the production setup is shown with the bottlenecks included. In this production setup you can see that Tokig salad spinner has two bottlenecks. The bottlenecks are for all Product Groups the injection machines. The average need of all these Product Groups are rather low, which makes it possible with this kind of advance sharing.



Consumption table

Below is the consumption table with the three Product Groups included.

Resource Group	Unit	Product Group: Tokig salad spinner	Bolmen toil roll holder	Bolmen S3	Capacity	Downtime rate (%)
		Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	(Unit/week)	
RM Tokig	kg	0,363			100000	
RM Bolmen roll holder	kg		0,12		100000	
RM S3 tooth brush	kg			0,1653	100000	
IM Tokig bowl	hours	0,005968992			288	12,00%
IM Tokig lid	hours	0,005622549			288	12,00%
IM Tokig net , S3 tooth brush mug lid & S3 soap bottom	hours	0,00634058		0,009416667	288	12,00%
IM Tokig knob, S3 dispenser lid, S3 Soap top	hours	0,001336806		0,004486111	144	12,00%
IM Tokig strainer 1, Bolmen roll holder knife & Bolmen roll holder support	hours	0,004301075	0,004930556		288	12,00%
IM Tokig insert	hours	0,003680556			144	12,00%
SM Tokig	hours	0,004169408			288	12,00%
IM Bolmen S3 mug	hours			0,004305556	144	20,00%
Bolmen S3 Assembly	hours			0,002777778	144	
Bolmen S3 Component	pieces			1	10000	
Bolmen roll Injection frame	hours		0,004861111		144	10,00%
Bolmen roll Assembly	hours		0,003472222		144	
TOKIG assembly & Packaging	hours	0,001555556			144	
Tool tokig net	hours	0,00634058			288	12,00%
Tool tokig strainer	hours	0,004301075			288	12,00%
Tool s3 toothbrush mug lid and soap bottom	hours			0,009416667	144	12,00%
Tool bolmen knife and support	hours		0,004930556		144	12,00%
Defect rate (%)		0,80%	1,30%	1,00%		
Average for 17 weeks from SPI, starting from the first week after the Lead time+1		15968	1312	2520		

Utilization of each Resource Group by Product Group

Resource Group	Utilization given average need			Utilization based on capacity allocated by need		
	Tokig salad spinner	Bolmen toil roll holder	Bolmen S3	Tokig salad spinner	Bolmen toil roll holder	Bolmen S3
RM Tokig	5,8%	0,0%	0,0%	11,8%	0,0%	0,0%
RM Bolmen roll holder	0,0%	0,2%	0,0%	0,0%	2,8%	0,0%
RM S3 tooth brush	0,0%	0,0%	0,4%	0,0%	0,0%	0,8%
IM Tokig bowl	37,9%	0,0%	0,0%	76,2%	0,0%	0,0%
IM Tokig lid	35,7%	0,0%	0,0%	71,8%	0,0%	0,0%
IM Tokig net , S3 tooth brush mug lid & S3 soap bottom	49,7%	0,0%	49,7%	100,0%	0,0%	100,0%
IM Tokig knob, S3 dispenser lid, S3 Soap top	26,0%	0,0%	26,0%	52,3%	0,0%	52,3%
IM Tokig strainer 1, Bolmen roll holder knife & Bolmen roll holder support	29,9%	29,9%	0,0%	99,9%	99,9%	0,0%
IM Tokig insert	46,7%	0,0%	0,0%	94,0%	0,0%	0,0%
SM Tokig	26,5%	0,0%	0,0%	53,3%	0,0%	0,0%
IM Bolmen S3 mug	0,0%	0,0%	9,5%	0,0%	0,0%	19,1%
Bolmen S3 Assembly	0,0%	0,0%	4,9%	0,0%	0,0%	9,9%
Bolmen S3 Component	0,0%	0,0%	25,5%	0,0%	0,0%	51,2%
Bolmen roll Injection frame	0,0%	5,0%	0,0%	0,0%	86,7%	0,0%
Bolmen roll Assembly	0,0%	3,2%	0,0%	0,0%	55,7%	0,0%
TOKIG assembly & Packaging	17,4%	0,0%	0,0%	35,0%	0,0%	0,0%
Tool tokig net	40,3%	0,0%	0,0%	81,0%	0,0%	0,0%
Tool tokig strainer	27,3%	0,0%	0,0%	54,9%	0,0%	0,0%
Tool s3 toothbrush mug lid and soap bottom	0,0%	0,0%	18,9%	0,0%	0,0%	38,0%
Tool bolmen knife and support	0,0%	5,2%	0,0%	0,0%	89,9%	0,0%

New Capacity figures

The capacity allocated by need is given in the table below. The capacities between the Product Groups will be changed when the SPI changes.

	Tokig salad spinner	Bolmen toil roll holder	Bolmen S3
Capacity Allocated by Need	32113	22818	5068

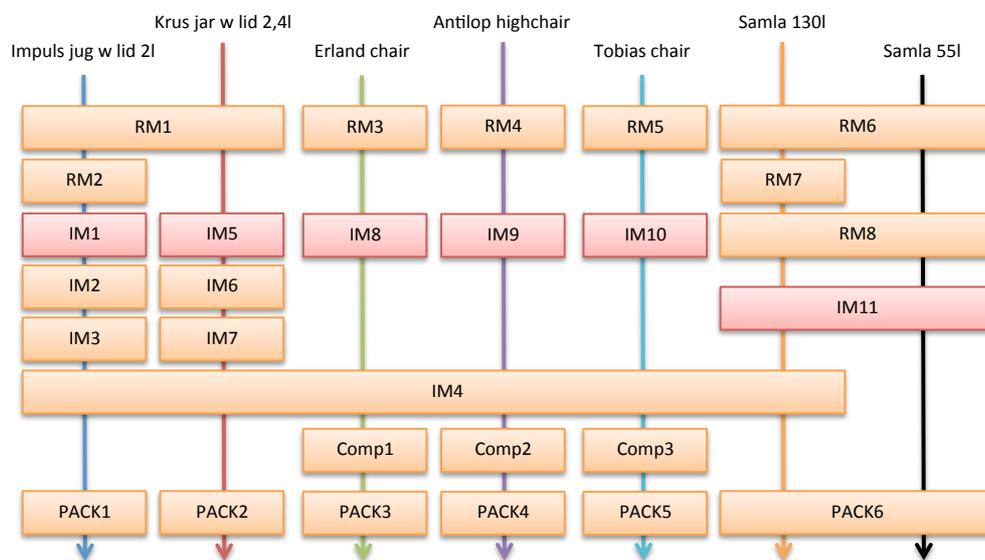
Appendix B - Reference case B

Case description

In this case 7 Product Groups share a production system. The bottlenecks identified given the values from the SPI forecast are not the bottlenecks when determining the maximum allocated net capacity.

Production setup

This is the production setup. Note that the bottlenecks highlighted in red are the bottlenecks when the capacity is maximized.



Consumption Table

The breakdown rates for B are all set at 4% as this is an estimate by them and they do not maintain the exact figures for this.

Product Group	Unit	Impuls jug w lid 2l	Krus jar w lid 2,4l	Samia 130l	Erland chair	Antliop highchair	Tobias chair	Samia 55l	Capacity	Downtime rate (%)
		Consumption rate (Unit/piece)								
RM AS	kg	0,348849	0,266997						38000	
RM ABS	kg	0,0675738							2000	
IM 36#	hours	0,000000006							80	4,00%
IM 42#	hours	0,00375							60	4,00%
IM 25#	hours	0,00388889							60	4,00%
IM 64#	hours	0,000972222	0,000644444	0,004444444	0,008333333	0,007777778	0,005277778		138	4,00%
ASSEMBLY Impuls	hours	0,002777778							78	
PACKING Impuls	hours	0,001388889							78	
RM ABS1	kg		0,0525252						19000	
RM TPE	kg		0,0040404						500	
IM 59#	hours		0,005						48	4,00%
IM 46#	hours		0,004722222						48	4,00%
IM 47#	hours		0,003333333						48	4,00%
SM TPE	hours		0,004444444						48	4,00%
ASSEMBLY KRUS	hours		0,004166667						48	
PACKING KRUS	hours		0,004166667						48	
RM PP	kg			3,7636364				1,4	34000	
RM POM	kg			0,018181825					180	
RM TPE1	kg			0,3019099				0,112	2000	
IM 50#	hours			0,026666667				0,014722222	138	4,00%
RM PP1	kg					1,135			17000	
RM LDPE	kg					0,0108			280	
COMP 1 Antliop	pieces					1			10000	
COMP 2 Antliop	pieces					1			10000	
IM 17#	hours					0,016666667			138	4,00%
PACKING Antliop highchr	hours					0,002777778			138	
RM PC	kg						3,6363636		4800	
RM TPE2	kg						0,0638384		50	
IM 1050#	hours						0,044444444		46	4,00%
COMP Tobias	pieces						1		1200	
RM HDPE	kg			0,0044					25	
RM PC/ABS	kg			3,0202					2000	
IM 1#	hours			0,041666667					23	4,00%
COMP Erland	pieces				1				5000	
Defect rate (%)		0,0205	0,0284	0,0378	0,03	0,025	0,0629	0,0499		
Average for 17 weeks from SP1, starting from the first week after the Lead time=1		10697	840	2009	144	5901	472	3617		

Utilization of Resource Groups by Product Groups

As shown in the image below the Resource Groups with the highest utilization for each Product Group shift when the capacity is determined.

Resource Group	Utilization given average need							Utilization based on capacity allocated by need						
	Impuls jug w lid 2l	Krus jar w lid 2,4l	Samia 130l	Erland chair	Antliop highchair	Tobias chair	Samia 55l	Impuls jug w lid 2l	Krus jar w lid 2,4l	Samia 130l	Erland chair	Antliop highchair	Tobias chair	Samia 55l
RM AS	10,7%	10,7%	0,0%	0,0%	0,0%	0,0%	0,0%	19,9%	19,9%	0,0%	0,0%	0,0%	0,0%	0,0%
RM ABS	36,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	46,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM 36#	79,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM 42#	71,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	90,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM 25#	72,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	92,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM 64#	53,9%	53,9%	53,9%	53,9%	53,9%	53,9%	0,0%	77,2%	77,2%	77,2%	77,2%	77,2%	77,2%	0,0%
ASSEMBLY Impuls	38,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	49,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
PACKING Impuls	19,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	24,6%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
RM ABS1	0,0%	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	2,5%	0,0%	0,0%	0,0%	0,0%	0,0%
RM TPE	0,0%	0,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	7,4%	0,0%	0,0%	0,0%	0,0%	0,0%
IM 59#	0,0%	9,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM 46#	0,0%	8,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	94,5%	0,0%	0,0%	0,0%	0,0%	0,0%
IM 47#	0,0%	6,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	66,7%	0,0%	0,0%	0,0%	0,0%	0,0%
SM TPE	0,0%	8,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	88,9%	0,0%	0,0%	0,0%	0,0%	0,0%
ASSEMBLY KRUS	0,0%	7,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	80,0%	0,0%	0,0%	0,0%	0,0%	0,0%
PACKING KRUS	0,0%	7,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	80,0%	0,0%	0,0%	0,0%	0,0%	0,0%
RM PP	0,0%	0,0%	38,7%	0,0%	0,0%	0,0%	38,7%	0,0%	0,0%	46,0%	0,0%	0,0%	0,0%	46,0%
RM POM	0,0%	0,0%	37,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	45,6%	0,0%	0,0%	0,0%	0,0%
RM TPE1	0,0%	0,0%	52,7%	0,0%	0,0%	0,0%	52,7%	0,0%	0,0%	52,6%	0,0%	0,0%	0,0%	52,6%
IM 50#	0,0%	0,0%	84,2%	0,0%	0,0%	0,0%	84,2%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	100,0%
RM PP1	0,0%	0,0%	0,0%	0,0%	40,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	53,1%	0,0%	0,0%
RM LDPE	0,0%	0,0%	0,0%	0,0%	31,8%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	41,7%	0,0%	0,0%
COMP 1 Antliop	0,0%	0,0%	0,0%	0,0%	60,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	79,5%	0,0%	0,0%
COMP 2 Antliop	0,0%	0,0%	0,0%	0,0%	60,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	79,5%	0,0%	0,0%
IM 17#	0,0%	0,0%	0,0%	0,0%	76,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%
PACKING Antliop highchr	0,0%	0,0%	0,0%	0,0%	12,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	16,0%	0,0%	0,0%
RM PC	0,0%	0,0%	0,0%	0,0%	0,0%	38,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	74,8%	0,0%
RM TPE2	0,0%	0,0%	0,0%	0,0%	0,0%	3,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	7,6%	0,0%
IM 1050#	0,0%	0,0%	0,0%	0,0%	0,0%	50,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	99,4%	0,0%
COMP Tobias	0,0%	0,0%	0,0%	0,0%	0,0%	41,8%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	82,3%	0,0%
RM HDPE	0,0%	0,0%	0,0%	2,6%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	9,3%	0,0%	0,0%	0,0%
RM PC/ABS	0,0%	0,0%	0,0%	22,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	79,9%	0,0%	0,0%	0,0%
IM 1#	0,0%	0,0%	0,0%	28,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	99,9%	0,0%	0,0%	0,0%
COMP Erland	0,0%	0,0%	0,0%	3,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	10,6%	0,0%	0,0%	0,0%

Resulting Capacities

The resulting capacities are shown below. Note that the overwrite capacities are the relevant figures and show where the iterative procedure was used.

	Impuls jug w lid 2l	Krus jar w lid 2,4l	Samla 130l	Erland chair	Antlop highchair	Tobias chair	Samla 55l
Capacity Allocated by Need	13547	1559	2387	268	7755	876	4298
Overwrite Capacity		8964		514		929	

Appendix C – Reference case C

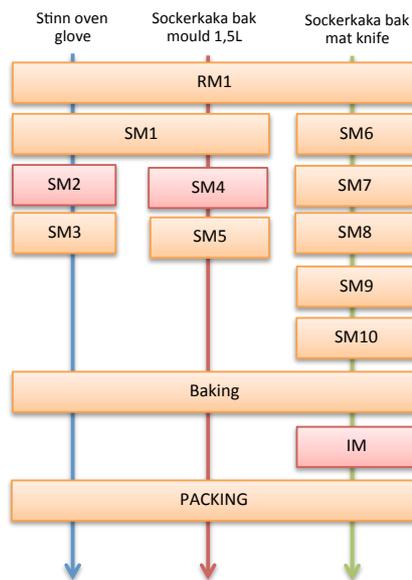
Case description

Three Product Groups shares a single or a number of Resource Groups. The products contain of the same raw material, silicone and are mainly produced by oil pressure, injection molding and assembling.

Production

setup

In Figure below the production setup is shown with the bottleneck identified by the red boxes. The bottlenecks identified in the production is the oilpressure machines and injection molding for the Sockerkaka



Consumption table

Product Group:		Stinn oven glove	Sockerkaka bak mould 1,5L	Sockerkaka bak mat knife	Capacity	Downtime
Resource Group	Unit	Consumption rate (Unit/ piece)	Consumption rate (Unit/ piece)	Consumption rate (Unit/ piece)	(Unit/week)	rate (%)
RM- Silicone	kg	0,115	0,19	0,106	10000	
SM- Color mix shared	hours	0,001152074	0,001901141		120	0,50%
SM-Oil pressure STINN	hours	0,045833333			480	3,00%
SM- Trimming	hours	0,008333333			480	
Baking	hours	0,000625	0,005514706	0,002604167	300	2,50%
Packing	hours	0,001296296	0,001666667	0,001833333	120	
SM Oil pressure Sockerkaka bakingmould heartshaped	hours		0,045833333		240	
SM trimming	hours		0,003333333		240	
SM colormix not shared	hours			0,005899705	120	
RM - Clothing	kg			0,065	624	
SM- Coating	hours			0,012218045	120	
SM- cutting	hours			0,00625	240	
SM - printing manually	hours			0,008333333	360	
SM- printing machine	hours			0,004166667	230	
RM- PP	kg			0,022	1000	
IM knife	hours			0,010416667	100	3,00%
Defect rate (%)		5,00%	5,00%	5,00%		
Average for 17 weeks from SPI, starting from the first week after the Lead time+1		18789	6150	5294		

Utilization of each Resource Group by Product Group

Resource Group	Utilization given average need			Utilization based on capacity allocated by need		
	Stinn oven glove	Socketkaka bak mould 1,5L	Socketkaka bak mat knife	Stinn oven glove	Socketkaka bak mould 1,5L	Socketkaka bak mat knife
RM- Silicone	40,8%	40,8%	40,8%	31,5%	31,5%	31,5%
SM- Color mix shared	29,3%	29,3%	0,0%	18,1%	18,1%	0,0%
SM-Oil pressure STINN	194,2%	0,0%	0,0%	100,0%	0,0%	0,0%
SM- Trimming	34,3%	0,0%	0,0%	17,6%	0,0%	0,0%
Baking	21,3%	21,3%	21,3%	20,3%	20,3%	20,3%
Packing	38,8%	38,8%	38,8%	32,5%	32,5%	32,5%
SM Oil pressure Socketkaka b	0,0%	123,3%	0,0%	0,0%	100,0%	0,0%
SM trimming	0,0%	9,0%	0,0%	0,0%	7,3%	0,0%
SM colormix not shared	0,0%	45,3%	45,3%	0,0%	60,3%	60,3%
RM - Clothing	0,0%	0,0%	57,9%	0,0%	0,0%	97,0%
SM- Coating	0,0%	0,0%	56,6%	0,0%	0,0%	94,8%
SM- cutting	0,0%	0,0%	14,5%	0,0%	0,0%	24,3%
SM - printing manually	0,0%	0,0%	12,9%	0,0%	0,0%	21,6%
SM- printing machine	0,0%	0,0%	10,1%	0,0%	0,0%	16,9%
RM- PP	55,6%	0,0%	55,6%	42,8%	0,0%	42,8%
IM knife	0,0%	0,0%	59,7%	0,0%	0,0%	100,0%

New Capacity figures

The new capacities calculated in the template gives the capacity allocated by the need. This is the capacity that should be inserted into GPS.

	Stinn oven glove	Socketkaka bak mould 1,5L	Socketkaka bak mat knife
Capacity Allocated by Need	9675	4988	8869
Overwrite Capacity			

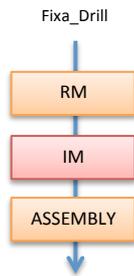
Appendix D - Reference case D

Case description

The Fixa Drill stencil is one of three products produced at D.

Production setup

As for all three IKEA products at D the Fixa Drill stencil is produced in a dedicated production line. One injection machine produces a part that is assembled onto a label in a time-consuming manner.



Consumption Table

The downtime and defect rates for F are set at 1%. The reason for the former is that the machines are new and rarely experience breakdowns, while the latter stems from a lack of maintaining information on defects.

Product Group:		FIXA_DRILL	Capacity	
Resource Group	Unit	Consumption rate (Unit/piece)	(Unit/week)	Downtime rate (%)
RM GPPS	KG	0,033	1360	
Injection18#	Hours	0,003055556	126	1,00%
Assembly	hours	0,002777778	126	
		Defect rate (%)	1,00%	
Average for 17 weeks from SPI, starting from the first week after the Lead time+1		9700		

Utilization of Resource Groups by Product Groups

In this simple case the injection machine is the bottleneck.

Resource Group	Utilization given average need		Utilization based on capacity allocated by need	
	FIXA_DRILL		FIXA_DRILL	
RM GPPS		23,8%		99,1%
Injection18#		24,0%		100,0%
Assembly		21,6%		90,0%

Resulting Capacities

The resulting capacities are shown below. As there is no sharing the capacity is constant and independent of the forecasted need.

Capacity Allocated by Need	FIXA_DRILL
	40420

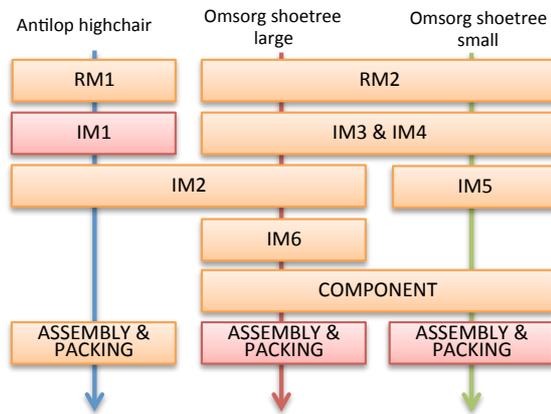
Appendix E - Reference Case E

Case description

Three Product Groups shares a single or a number of Resource Groups. The products contain two raw materials and is produced by injection molding, components and is assembled together to the end product.

Production setup

The setup is pretty simple with some sharing mainly because of small quantities.



Consumption table

This table below describes respective Product Groups consumption of each Resource Group (Unit per piece). The defect rates is derived from historical data and the average need is from the SPI.

Product Group:		Antilop highchair	Omsorg shoetree large	Omsorg shoetree small	Capacity	Downtime rate (%)
Resource Group	Unit	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	(Unit/week)	
RM	kg	1,156			100000	
IM ANTILOP CHAIR	hours	0,017222222			120	
IM ANTILOP FEET & OMSORG TREE LARGE FAN	hours	0,004444444	0,0025		240	
ASSEMBLY & PACKING Antilop	hours	0,011111111			120	
RM Omsorg	kg		0,056	0,038	100000	
IM Base small & large	hours		0,001111111	0,001111111	240	
ASSEMBLY & PACKING Omsorg large	hours		0,004444444		240	
OMSORG COMPONENT	pieces		2	2	2000000	
IM fan small	hours			0,0025	240	
ASSEMBLY & PACKING Omsorg small	hours			0,004444444	240	
Tool antilop feet	hours	0,004444444			120	
Tool omsorg tree large fan	hours		0,0025		240	
Defect rate (%)		1,00%	0,30%	0,30%		
Average for 17 weeks from SPI, starting from the first week after the Lead time+1		6081	21910	7841		

Utilization of each Resource Group by Product Group

The table below shows the different Resource Groups utilization from each Product Group and the template will automatically show the bottlenecks with the highest utilization in red. As we can see in the table the IM "ANTILOP CHAIR", ASSEMBLY & PACKING Omsorg large and ASSEMBLY & PACKING Omsorg small is the bottlenecks.

Resource Group	Utilization given average need			Utilization based on capacity allocated by need		
	Antilop highchair	Omsorg shoetree large	Omsorg shoetree small	Antilop highchair	Omsorg shoetree large	Omsorg shoetree small
RM	7,1%	0,0%	0,0%	8,1%	0,0%	0,0%
IM ANTILOP CHAIR	88,1%	0,0%	0,0%	100,0%	0,0%	0,0%
IM ANTILOP FEET & OMSORG TREE LARGE FAN	34,3%	34,3%	0,0%	69,2%	69,2%	0,0%
ASSEMBLY & PACKING Antilop	56,9%	0,0%	0,0%	64,5%	0,0%	0,0%
RM Omsorg	0,0%	1,5%	1,5%	0,0%	5,1%	5,1%
IM Base small & large	0,0%	13,8%	13,8%	0,0%	50,0%	50,0%
ASSEMBLY & PACKING Omsorg large	0,0%	40,7%	0,0%	0,0%	100,0%	0,0%
OMSORG COMPONENT	0,0%	3,0%	3,0%	0,0%	10,8%	10,8%
IM fan small	0,0%	0,0%	8,2%	0,0%	0,0%	56,3%
ASSEMBLY & PACKING Omsorg small	0,0%	0,0%	14,6%	0,0%	0,0%	100,0%
Tool antilop feet	22,7%	0,0%	0,0%	25,8%	0,0%	0,0%
Tool omsorg tree large fan	0,0%	22,9%	0,0%	0,0%	56,3%	0,0%

Resulting Capacities

The new capacities calculated in the template gives the capacity allocated by the need. This is the capacity that should be inserted into GPS. Because the Omsorg shoetree large and small has the same assembly and packing time and this is the bottleneck, they gets the same capacity number as shown in table below.

	Antilop highchair	Omsorg shoetree large	Omsorg shoetree small
Capacity Allocated by Need	6899	53839	53839
Overwrite Capacity			

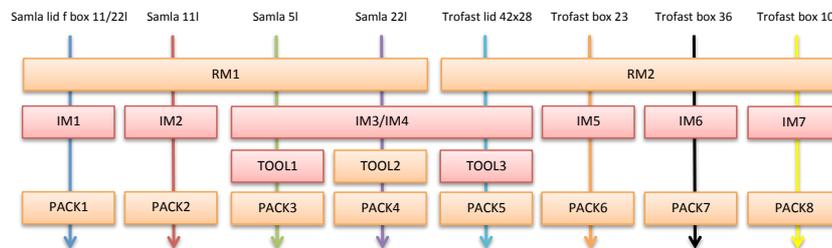
Appendix F - Reference case F

Case description

At the time of the visit to F the production of Samla 22l box had not started yet, but was due to start in the near future. This Product Group's tool was to be used in two injection machines currently dedicated to two separate products. This meant that all Product Groups could use both injection machines in that Resource Groups but not at the same time. Therefore the tool capacity is used to constrain the capacity.

Production setup

Without any current need for the Samla 22l box the two injection machines are essentially dedicated Samla 5l box and Trofast lid respectively. This means that the Resource Groups IM3/IM4 is the bottleneck and the capacity allocation is restricted by the fact that each Product Group only has one tool.



Consumption Table

The breakdown rates for F are set at 2.5% and the defect rates are set at 2%. This is because they currently do not maintain figures for it and have chosen these figures from experience. The figures for the weekly capacities of the raw materials are entered as a high figure as they have no figures for this either.

Resource Group	Unit	Product Group								Capacity	Downtime rate (%)	
		Samla 5l	Samla 11l	Samla 5l f box 11/22l	Samla 22l	Trofast lid 10	Trofast lid 23	Trofast lid 36	Trofast lid 42x28			
		Consumption rate (Unit/price)										
Raw Material 30l	Kg	0,214	0,42111	0,194							10000	
packing samla 5l box	hours	0,002138889									138	
injection 33#	hours	0,008055556									138	2,50%
packing samla 11l box	pieces	0,008055556									138	
injection 34#	hours			0,006111111							138	2,50%
packing samla 11l lid	hours			0,000527778							138	
packe samla 22l box	hours											
injection 36#	hours											
packe samla 5l lid	hours											
Raw Material B1950	Kg				0,35247	0,54435	0,78536	0,18162			100000	
injection 32#	hours				0,0075						138	2,50%
packing trofast 10h box	hours				0,002155278						138	
injection 33#	hours								0,008333333		138	2,50%
packing trofast 23h box	hours								0,001666667		138	
injection 34#	hours								0,001666667		138	2,50%
packing trofast 36 box	hours								0,002083333		138	
packing trofast lid	hours								0,0003125		138	
injection 29#_30#	hours	0,003194444			0,006388889				0,003333333		276	2,50%
tool s18 (injection 29#_30#)	hours	0,003194444			0,006388889				0,003333333		138	2,50%
tool s22h (injection 29#_30#)	hours								0,003333333		138	2,50%
tool s1 (injection 29#_30#)	hours								0,003333333		138	2,50%
Defect rate (%)		2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%		
Average for 17 weeks from BPA, starting from the first week after the Lead time 5		29100	16042	24669	0	5964	5029	2127	16141			

Utilization of Resource Groups by Product Groups

In this case the bottlenecks are currently not shared and when the raw material is disregarded the production can be viewed as several line productions, one dedicated to each Product Group. This will however change with the start of production of the Samla 221 box.

Resource Group	Utilization given average need								Utilization based on capacity allocated by need							
	Samla 51	Samla 111	Samla lid f box 11/221	Samla 221	Trofost box 10	Trofost box 23	Trofost box 36	Trofost lid 42x28	Samla 51	Samla 111	Samla lid f box 11/221	Samla 221	Trofost box 10	Trofost box 23	Trofost box 36	Trofost lid 42x28
Raw Material 348	17,4%	17,4%	17,4%	0,0%	0,0%	0,0%	0,0%	0,0%	19,7%	19,7%	19,7%	0,0%	0,0%	0,0%	0,0%	0,0%
packing samla 51 box	46,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	65,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
injection 33#	0,0%	96,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
packing samla 111 box	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
injection 34#	0,0%	0,0%	115,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
packing samla 111 lid	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
packa samla 221 box	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
injection 36#	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
packa samla 51 lid	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Raw Material B3550	0,0%	0,0%	0,0%	0,0%	9,6%	9,6%	9,6%	9,6%	0,0%	0,0%	0,0%	0,0%	34,0%	34,0%	34,0%	34,0%
injection 32#	0,0%	0,0%	0,0%	0,0%	33,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%
packing trofast 10h box	0,0%	0,0%	0,0%	0,0%	9,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	28,0%	0,0%	0,0%	0,0%
injection 33#	0,0%	0,0%	0,0%	0,0%	0,0%	31,8%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%
packing trofast 23h box	0,0%	0,0%	0,0%	0,0%	0,0%	6,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	19,5%	0,0%	0,0%
injection 34#	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	14,8%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%
packing trofast 36 box	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	3,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	22,2%	0,0%
packing trofast lid	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	3,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	9,1%
injection 29#, 30#	35,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	99,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	99,9%
tool s51b (injection 29#, 30#)	70,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
tool s221b (injection 29#, 30#)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
tool t1 (injection 29#, 30#)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	99,7%

Resulting Capacities

The resulting capacities are shown below. Note that the overwrite capacity is the relevant figure and shows where the iterative procedure was used. The capacity here for the Samla 221 box is 0 as production has not started.

	Samla 51	Samla 111	Samla lid f box 11/221	Samla 221	Trofost box 10	Trofost box 23	Trofost box 36	Trofost lid 42x28
Capacity Allocated by Need	41293	16376	21586	0	17589	15830	14391	29016
Overwrite Capacity								39462

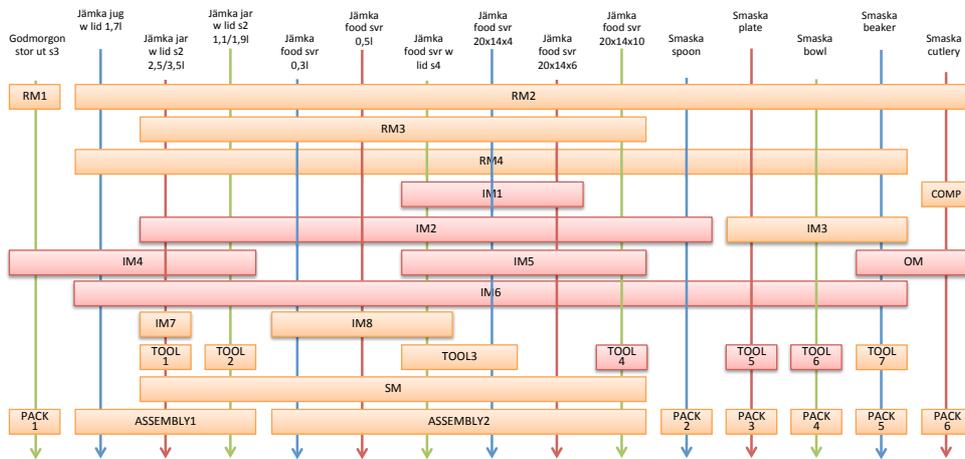
Appendix G - Reference case G

Case description

This is the most complicated case experienced in this thesis. 15 Product Groups belong to the same production as they share Resource Groups in a very complicated manner. The case also contains the complication of Product Groups using Resource Groups without being able to use the entire capacity of those Resource Groups due to a restricted number of tools.

Production setup

The production looks as follows with the bottlenecks highlighted:



Consumption Table

For the purpose of presenting the consumption table on these pages in an esthetic way it is split into two to fit the page, but in the template it is maintained as one long table.

Utilization based on capacity allocated by need

Resource Group	JAMKA_FOOD_S VW_0,3L	JAMKA_FOOD_S VW_0,5L	JAMKA_FOOD_S VW_W_LID_1,1	JAMKA_FOOD_S VW_20X14X4	JAMKA_FOOD_S VW_20X14X4	JAMKA_FOOD_S VW_20X14X4	JAMKA_FOOD_S VW_20X14X4	SMASKA_SPOON	SMASKA_PLATE	SMASKA_CUTLERY	SMASKA_BEAKER	SMASKA_BOWL	JAMKA_JAR_WITH LID_S2_1,1/1,9L	JAMKA_JAR_WITH LID_S2_2,5/3,5L	JAMKA_JUG_WITH LID_1,7L	GOMORGON_STO R_UT_S3
BM PPR	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%	32.4%
BM PFC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
COMP SMASKA_CUTLERY	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
IM #9/#10/#11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	74.3%	0.0%	0.0%	0.0%	74.3%	0.0%	0.0%	0.0%
IM #12	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
IM #13/#14/#15	0.0%	0.0%	100.0%	100.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%
IM #16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%
IM #5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	32.2%	0.0%	32.2%	0.0%
IM #10	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
IM #17	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
IM #18	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	0.0%	0.0%
IM #19	62.4%	62.4%	62.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
IM SHIRINK JAMKA	39.1%	39.1%	39.1%	39.1%	39.1%	39.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.1%	39.1%	0.0%	0.0%
ASSEMBLY JAMKA JARS	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	1.8%	0.0%	0.0%
ASSEMBLY JAMKA	14.1%	14.1%	14.1%	14.1%	14.1%	14.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOOL JAMKA_JAR_1,1/1,9L IM#13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	4.6%	0.0%	0.0%
TOOL JAMKA_JAR_2,5/3,5L IM#13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.4%	0.0%	0.0%
TOOL SMASKA_BEAKER IM#11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.8%	0.0%	0.0%	0.0%	0.0%	0.0%
TOOL JAMKA_WL_BOX	0.0%	0.0%	72.3%	72.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOOL JAMKA_WL_BOX	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PACK SMASKA_SPOON	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PACK SMASKA_PLATE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PACK SMASKA_CUTLERY	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PACK SMASKA_BEAKER	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PACK SMASKA_BOWL	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PACK JAMKA JUG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOOL SMASKA_BOWL	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
TOOL SMASKA_PLATE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
IM PFC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	45.2%
ASSEMBLY GOMORGON	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	53.3%

Resulting Capacities

The resulting capacities are shown below. Note that the overwrite capacity is the relevant figure and shows where the iterative procedure was used. Because of the complexity of the production setup the iterative procedure was used for 10 of the 15 Product Groups.

	JAMKA_FOOD_SVR 0,3L	JAMKA_FOOD_SVR 0,5L	JAMKA_FOOD_SVR W_LID_1,1	JAMKA_FOOD_SVR 20X14X4	JAMKA_FOOD_SVR 20X14X4	JAMKA_FOOD_SVR 20X14X10	SMASKA_SPOON	SMASKA_PLATE
Capacity Allocated by Need	3830	4952	9023	5687	17441	12084	12139	27337
Overwrite Capacity	4133	5343	9736	7791	21976		21850	

	SMASKA_CUTLERY	SMASKA_BEAKER	SMASKA_BOWL	JAMKA_JAR_WITH LID_S2_1,1/1,9L	JAMKA_JAR_WITH LID_S2_2,5/3,5L	JAMKA_JUG_WITH LID_1,7L	GOMORGON_STOR UT_S3
Capacity Allocated by Need	9284	10369	25610	2547	4524	3456	3862
Overwrite Capacity				2748	4881	3729	5310

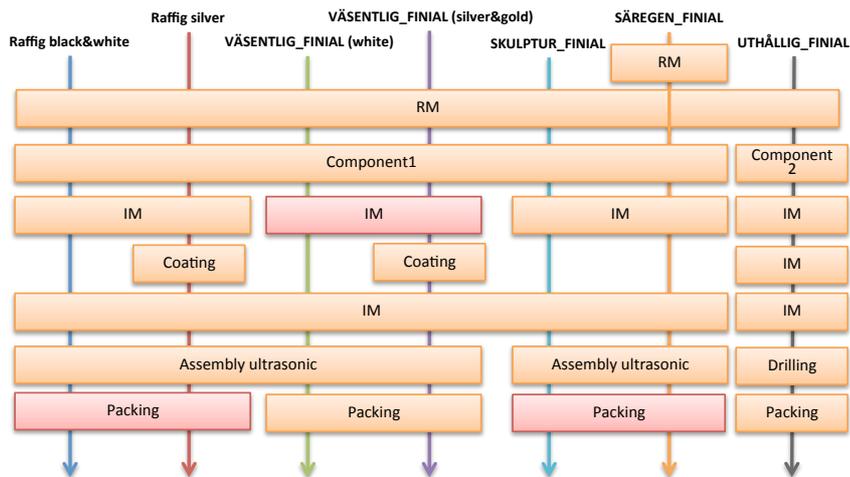
Appendix H - Reference case H

Case description

Five Product Groups shares a single or a number of Resource Groups. The products contain of two bottom parts and two top parts that is assembled together into two parts that together is the end product. The bottom part will be done by over mold and will have a screw fixed to it and injection molding does the top part.

Production setup

The production setup could be shown below and the bottlenecks in the system are marked with red boxes. Product Group Uthållig have no average need and the bottleneck could not be marked out in its production setup. The reason for that the packing is bottleneck in this production setup is because the average need is very low and for that cause they have reduced the packing to just work one-shift instead of two-shifts as before. This also means that the bottleneck easily could be adjusted and new bottlenecks will be found.



Consumption table

Product Group:		RAFFIG (black&white)	RAFFIG (silver)	VÄSENTLIG_FINAL (white)	VÄSENTLIG_FINAL (silver&gold)	SKULPTUR_FINAL	SÄREGEN_FINAL	UTHÄLLIG_FINAL	Capacity	Downtime rate (%)
Resource Group	Unit	Consumption rate (Unit/piece)	(Unit/week)							
RM HPS	kg	0,1114	0,1082	0,084	0,084	0,0716		0,3088	1000000	
Component screw short (10mm)	pieces	2	2	2	2	2	2		500000	
IM C1-B1-C2 top	hours	0,001515508	0,001515508	0,000842105					330	
Coating outsourced	hours								40	
IM A7-A8-F3-F7-A10-A11 bottom	hours	0,001840278	0,001840278	0,002604167	0,002604167	0,002361111	0,00256944		660	
Assembly Ultrasonic 4 big	hours	0,001111111	0,001111111	0,001666667	0,001666667				440	
Packaging raffig	hours	0,002083333	0,002083333						225	
RM PS	kg						0,0988		12000	
Component screw long (73mm)	pieces							2	150000	
IM F2, F5 and F6- top	hours		0,004861111	0,004861111					330	
Packaging outsourced	hours		0,002083333	0,002083333					150	
Coating väsentlig silver&gold	hours			0,000842105					40	
IM B2, B3- top	hours					0,004166667	0,007222222		220	
Ultrasonic small 3 machines	hours					0,003333333	0,003891051		225	
Packaging säregen &skulptur	hours					0,001082251	0,002083333		37,5	
IM A4- biggest grey	hours							0,012777778	110	
IM A2- middle beach	hours							0,012222222	110	
IM A3- smallest white	hours							0,013888889	110	
Drilling1	hours							0,001666667	37,5	
Drilling2	hours							0,001666667	37,5	
Drilling3	hours							0,001666667	37,5	
Packing uthållig	hours							0,001805556	37,5	
Tooling capacity raffig bottom	hours	0,001840278	0,001840278						440	
Tooling capacity raffig top	hours	0,001515508	0,001515508						440	
Tooling capacity väsentlig bottom	hours			0,002604167	0,002604167				220	
Tooling capacity väsentlig top	hours			0,004861111	0,004861111				440	
Tooling capacity Skulptur bottom	hours					0,002361111			110	
Tooling capacity Skulptur top	hours					0,004166667			110	
Tooling capacity Säregen bottom	hours						0,00256944		110	
Tooling capacity Säregen top	hours						0,007222222		110	
Defect rate (%)		1,00%	1,00%	1,00%	1,00%	1,00%	1,00%	1,00%		
Average for 17 weeks from SP1, starting from the first week after the Lead time+1		8983	4574	17409	4051	4671	356	0		

Utilization of each Resource Group by Product Group

Resource Group	Utilization given average need							
	RAFFIG (black&white)	RAFFIG (silver)	VÄSENTLIG_FINAL (white)	VÄSENTLIG_FINAL (silver&gold)	SKULPTUR_FINAL	SÄREGEN_FINAL	UTHÄLLIG_FINAL	
RM HPS	0,4%	0,4%	0,4%	0,4%	0,4%	0,4%	0,0%	0,0%
Component screw short (10mm)	17,0%	17,0%	17,0%	17,0%	17,0%	17,0%	17,0%	0,0%
IM C1-B1-C2 top	6,3%	6,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Coating outsourced	0,0%	9,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM A7-A8-F3-F7-A10-A11 bottom	14,9%	14,9%	14,9%	14,9%	14,9%	14,9%	14,9%	0,0%
Assembly Ultrasonic 4 big	11,7%	11,7%	11,7%	11,7%	11,7%	0,0%	0,0%	0,0%
Packaging raffig	12,7%	12,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
RM PS	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,3%	0,0%
Component screw long (73mm)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM F2, F5 and F6- top	0,0%	0,0%	31,9%	31,9%	0,0%	0,0%	0,0%	0,0%
Packaging outsourced	0,0%	0,0%	30,1%	30,1%	0,0%	0,0%	0,0%	0,0%
Coating väsentlig silver&gold	0,0%	0,0%	0,0%	8,6%	0,0%	0,0%	0,0%	0,0%
IM B2, B3- top	0,0%	0,0%	0,0%	0,0%	13,9%	13,9%	0,0%	0,0%
Ultrasonic small 3 machines	0,0%	0,0%	0,0%	0,0%	10,6%	10,6%	0,0%	0,0%
Packaging säregen &skulptur	0,0%	0,0%	0,0%	0,0%	21,4%	21,4%	0,0%	0,0%
IM A4- biggest grey	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM A2- middle beach	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM A3- smallest white	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Drilling1	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Drilling2	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Drilling3	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Packing uthållig	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Tooling capacity raffig bottom	5,7%	5,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Tooling capacity raffig top	4,7%	4,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Tooling capacity väsentlig bottom	0,0%	0,0%	25,7%	25,7%	0,0%	0,0%	0,0%	0,0%
Tooling capacity väsentlig top	0,0%	0,0%	23,9%	23,9%	0,0%	0,0%	0,0%	0,0%
Tooling capacity Skulptur bottom	0,0%	0,0%	0,0%	0,0%	14,5%	0,0%	0,0%	0,0%
Tooling capacity Skulptur top	0,0%	0,0%	0,0%	0,0%	25,5%	0,0%	0,0%	0,0%
Tooling capacity Säregen bottom	0,0%	0,0%	0,0%	0,0%	0,0%	0,7%	0,0%	0,0%
Tooling capacity Säregen top	0,0%	0,0%	0,0%	0,0%	0,0%	2,4%	0,0%	0,0%

Utilization based on capacity allocated by need

Resource Group	RAFFIG (black&white)	RAFFIG (silver)	VÄSENTLIG_FINIAL (white)	VÄSENTLIG_FINIAL (silver&gold)	SKULPTUR_FINIAL	SÄREGEN_FINIAL	UTHÄLLIG_FINIAL
RM HPS	2,0%	2,0%	2,0%	2,0%	2,0%	0,0%	0,0%
Component screw short (10mm)	82,6%	82,6%	82,6%	82,6%	82,6%	82,6%	0,0%
IM C1-B1-C2 top	49,6%	49,6%	0,0%	0,0%	0,0%	0,0%	0,0%
Coating outsourced	0,0%	76,7%	0,0%	0,0%	0,0%	0,0%	0,0%
IM A7-A8-F3-F7-A10-A11 bottom	67,8%	67,8%	67,8%	67,8%	67,8%	67,8%	0,0%
Assembly Ultrasonic 4 big	53,0%	53,0%	53,0%	53,0%	0,0%	0,0%	0,0%
Packaging raffig	100,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
RM PS	0,0%	0,0%	0,0%	0,0%	0,0%	3,5%	0,0%
Component screw long (73mm)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM F2, F5 and F6- top	0,0%	0,0%	100,0%	100,0%	0,0%	0,0%	0,0%
Packaging outsourced	0,0%	0,0%	94,3%	94,3%	0,0%	0,0%	0,0%
Coating väsentlig silver&gold	0,0%	0,0%	0,0%	27,0%	0,0%	0,0%	0,0%
IM B2, B3- top	0,0%	0,0%	0,0%	0,0%	64,0%	64,0%	0,0%
Ultrasonic small 3 machines	0,0%	0,0%	0,0%	0,0%	46,5%	46,5%	0,0%
Packaging säregen &skulptur	0,0%	0,0%	0,0%	0,0%	100,0%	100,0%	0,0%
IM A4- biggest grey	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM A2- middle beach	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IM A3 - smallest white	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Drilling1	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Drilling2	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Drilling3	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Packing uthällig	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Tooling capacity raffig bottom	45,2%	45,2%	0,0%	0,0%	0,0%	0,0%	0,0%
Tooling capacity raffig top	37,2%	37,2%	0,0%	0,0%	0,0%	0,0%	0,0%
Tooling capacity väsentlig bottom	0,0%	0,0%	80,4%	80,4%	0,0%	0,0%	0,0%
Tooling capacity väsentlig top	0,0%	0,0%	75,0%	75,0%	0,0%	0,0%	0,0%
Tooling capacity Skulptur bottom	0,0%	0,0%	0,0%	0,0%	56,7%	0,0%	0,0%
Tooling capacity Skulptur top	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%
Tooling capacity Säregen bottom	0,0%	0,0%	0,0%	0,0%	0,0%	8,8%	0,0%
Tooling capacity Säregen top	0,0%	0,0%	0,0%	0,0%	0,0%	28,1%	0,0%

New Capacity figures

The capacity allocated by need is given in the table below. Important to notice is that the when there are numbers in the yellow boxes (overwrite capacity) this numbers is the capacity of the Product Group. The Product Group Raffig for example consists of 70861 pieces of Raffig (black &white) and 36081 pieces of Raffig (silver), which that the capacity that should be register for Raffig is $70851+36082=106933$ pieces.

	RAFFIG (black&white)	RAFFIG (silver)	VÄSENTLIG_FINIAL (white)	VÄSENTLIG_FINIAL (silver&gold)	SKULPTUR_FINIAL	SÄREGEN_FINIAL	UTHÄLLIG_FINIAL
Capacity Allocated by Need	52881	26926	54521	12687	26136	1661	0
Overwrite Capacity	70861	36081				4236	

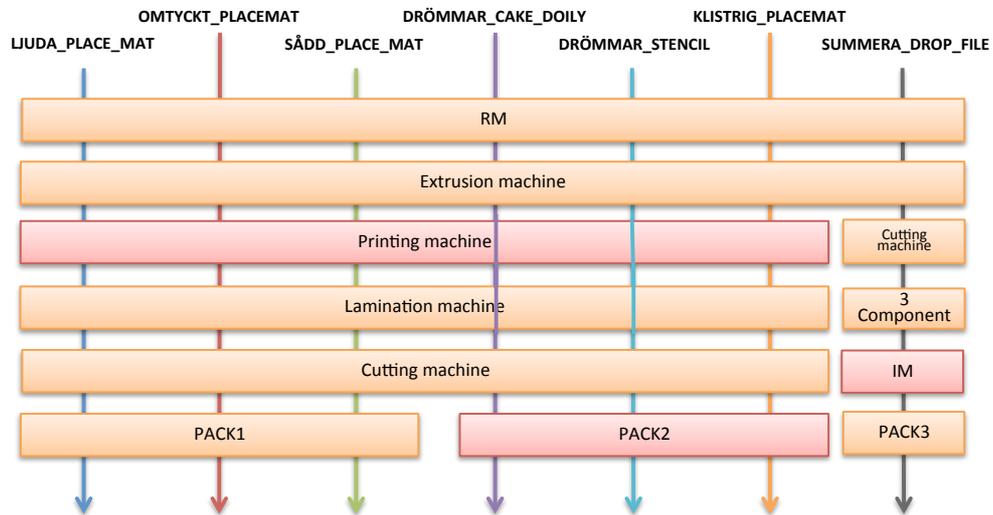
Appendix I - Reference case I

Case description

Seven Product Groups shares a single or a number of Resource Groups. All Product Groups mainly follow these production steps; extrusion, cutting and printing. They all share the same rawmaterial and the extrusion machine.

Production setup

The production setup could be shown below and the bottlenecks in the system are marked with red boxes. Note that both Product Groups Drömmar do not use the printing machine shown by having no lines going below that Resource Group.



Consumption table

Product Group:	LJUDA_PLACE_MAT	OMTYCKT_PLACEMAT	SÄDD_PLACE_MAT	DRÖMMAR_CAKE_DOILY	DRÖMMAR_STENCIL	KLISTRIG_PLACEMAT	SUMMERA_DROP_FILE	Capacity	Downtime rate (%)	
Resource Group	Unit	Consumption rate (Unit/ piece)	(Unit/ week)							
RM - PP Ho	kg	0,000682023	0,000682023	0,000682023	0,000520419	0,11	0,2218	165000	3,30%	
Extrusion Machine	hours	0,000166667	0,000166667	0,000166667	0,000580929	0,001190476	0,003787879	420	3,30%	
Printing Machine P1	hours	0,000166667	0,000166667	0,000166667		0,000333333		50	0,70%	
Lamination Machine-L1->3	hours	0,000166667	0,000166667	0,000166667	0,000333333	0,000333333		330	2,27%	
Cutting Machine C1->2	hours	0,000166667	0,000166667	0,000166667	0,000333333	0,000333333		220	2,27%	
Packing and labelling	hours	0,000277778	0,000277778	0,000277778				225	2,22%	
Packaging P2	hours				0,002777778	0,002777778	0,002777778		337,5	
Cutting Machine A1	hours						0,015353536	247,5	3,30%	
Packaging P3	hours						0,00025	121,75		
Component PET index	pieces						16	384000		
Component paper index	pieces						1	200000		
Component PP hangers	pieces						32	600000		
IM - Packing box	hours						0,008333333	120	1,60%	
Defect rate (%)		2,00%	2,00%	2,00%	3,00%	3,00%	2,00%			
Average for 17 weeks from SP1, starting from the first week after the Lead time +1		67000	45318	16518	2306	1705	37312	2314		

Utilization of each Resource Group by Product Group

Utilization given average need

Resource Group	LJUDA_PLACE_MAT	OMTYCKT_PLACEM AT	SÄDD_PLACE_MAT	DRÖMMAR_CAKE_D OILY	DRÖMMAR_STENCI L	KLISTRIG_PLACEM AT	SUMMERA_DROP_F ILE
RM -PP Ho	2,3%	2,3%	2,3%	2,3%	2,3%	2,3%	2,3%
Extrusion Machine	36,0%	36,0%	36,0%	36,0%	36,0%	36,0%	36,0%
Printing Machine P1	69,7%	69,7%	69,7%	0,0%	0,0%	69,7%	0,0%
Lamination Machine-L1~3	10,7%	10,7%	10,7%	0,0%	0,0%	10,7%	0,0%
Cutting Machine C1~2	16,7%	16,7%	16,7%	16,7%	16,7%	16,7%	0,0%
Packing and labeling	16,6%	16,6%	16,6%	0,0%	0,0%	0,0%	0,0%
Packaging P2	0,0%	0,0%	0,0%	34,7%	34,7%	34,7%	0,0%
Cutting Machine A1	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	15,0%
Packaging P3	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	12,4%
Component PET index	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	9,9%
Component paper index	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	1,2%
Component PP hangers	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	12,7%
IM - Packing box	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	16,8%

Utilization basen on capacity allocated by need

Resource Group	LJUDA_PLACE_MAT	OMTYCKT_PLACEM AT	SÄDD_PLACE_MAT	DRÖMMAR_CAKE_D OILY	DRÖMMAR_STENCI L	KLISTRIG_PLACEM AT	SUMMERA_DROP_F ILE
RM -PP Ho	4,9%	4,9%	4,9%	4,9%	4,9%	4,9%	4,9%
Extrusion Machine	69,9%	69,9%	69,9%	69,9%	69,9%	69,9%	69,9%
Printing Machine P1	100,0%	100,0%	100,0%	0,0%	0,0%	100,0%	0,0%
Lamination Machine-L1~3	15,4%	15,4%	15,4%	0,0%	0,0%	15,4%	0,0%
Cutting Machine C1~2	33,5%	33,5%	33,5%	33,5%	33,5%	33,5%	0,0%
Packing and labeling	23,8%	23,8%	23,8%	0,0%	0,0%	0,0%	0,0%
Packaging P2	0,0%	0,0%	0,0%	100,0%	100,0%	100,0%	0,0%
Cutting Machine A1	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	89,1%
Packaging P3	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	74,0%
Component PET index	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	59,0%
Component paper index	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	7,1%
Component PP hangers	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	75,6%
IM - Packing box	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%

New Capacity figures

The capacity allocated by need is given in the table below. Important to notice is that when there are numbers in the yellow boxes (overwrite capacity) this number is the capacity of the Product Group. For example the capacity for DRÖMMAR_CAKE_DOILY is 37347 pieces.

	LJUDA_PLACE_MAT	OMTYCKT_PLACEMAT	SÄDD_PLACE_MAT	DRÖMMAR_CAKE_DOILY	DRÖMMAR_STENCIL	KLISTRIG_PLACEMAT	SUMMERA_DROP_FILE
Capacity Allocated by Need	96176	65053	23711	6406	4736	53560	6428
Overwrite Capacity				37347	27611		13756

Appendix J - Mathematical Model

In order to calculate the gross capacity in units for the Product Groups of a certain supplier the authors have developed a mathematical model.

Model Notation

The following variables are used in the model:

o_{ij}	standard operating time (in seconds) required for unique resource i per article j
O_{il}	standard operating time (in seconds) required for unique resource i per Product Group l
b_{ij}	standard consumption rate (in hours per piece) of unique resource i per article j
B_{il}	standard consumption rate (in hours per piece) of unique resource i Product Group l
C_{kl}	standard consumption rate (in hours per piece) of Resource Group k per Product Group l
q_l	defect rate for Product Group l
r_i	downtime rate for unique resource i
R_k	downtime rate for Resource Group k
F_{kl}	failure rate for the Resource Group k for Product Group l
A_i	amount of available unique resources i
P_i	amount of pieces contributed to per cycle in unique resource i
d_i	dedicated weekly capacity (gross capacity in hours for machines and labor) per unique resource i
D_k	dedicated weekly capacity (gross capacity in hours for machines and labor) per Resource Group k
n_j	average forecasted weekly need of article j determined from the SPI
N_l	average forecasted weekly need of Product Group l determined from the SPI
E_l	allocated maximum capacity of Product Group l
U_k	utilization of Resource Group k
I_k	all unique resources within Resource Group k
J_l	all unique resources within Resource Group l
K	all Resource Groups within a certain production line
L	all Product Groups within a certain production line

Consumption Rate Calculation

First it is important to note that there are two different types of unique resources. One type is time dependent resources (TD) including machine or labor hours and the other is material dependent resources (MD) including raw materials and components. This means that the consumption rate is calculated with a different approach for each.

Once the required data is collected for a production line the next step is to group unique resources into resource groups. This is an objective task and can therefore not be mathematically modeled. The model hence starts after this step.

In order to calculate the consumption rate or cycle time for a Product Group a weighted average is calculated related to the forecasted average weekly demand from the SPI as follows:

$$B_{il} = \sum_j \frac{b_{ij}n_j}{n_j} \quad j \in J_l$$

$$O_{il} = \sum_j \frac{o_{ij}f_j}{f_j} \quad j \in J_l$$

The consumption rate of MD resources is determined by how much of that resource is required for each end product of article i , while the consumption rate of TD resources must be calculated from the cycle time data.

MD resources are never grouped with other unique resources into Resource Groups and are therefore always Type I. The consumption rate is therefore as follows:

$$C_{kl,MD} = B_{il} \quad i \in I_k$$

Consumption rates for the three different types of Resource Groups are calculated as follows:

Type I. This is a group consisting of one type of unique resource and the consumption rate is converted from seconds per piece to hours per piece:

$$C_{kl,TD,Type I} = \frac{O_{il}}{P_i * 3600} \quad i \in I_k$$

Type II. As this is a group of consecutive unique resources the bottleneck determines the consumption rate. The bottleneck is found by determining each unique resources weekly capacity and seeing which one has the lowest, then the consumption rate for this one is calculated:

$$C_{kl,TD,Type II} = \frac{O_{il}}{P_i * 3600} \left\{ i = \max_{i \in I_k} \left(\frac{d_i A_i P_i * 3600}{O_{il}} \right) \right\}$$

Where the gross weekly capacity in pieces of each unique resource i is:

$$\frac{d_i A_i P_i * 3600}{O_{il}}$$

Type III. For this grouping of parallel unique resources an average consumption rate is calculated. This is done by dividing the total dedicated weekly capacity in hours of all individual machines by the total calculated weekly gross capacity for the group:

$$C_{kl,TD,Type III} = \frac{\sum_{i \in I_k} A_i d_i}{\sum_{i \in I_k} \frac{d_i A_i P_i 3600}{O_{il}}}$$

Utilization

Utilization is calculated for each Resource Group for both forecasted need and allocated maximum capacity. To calculate this first determine the need of each Resource Group by each Product Group. This need is calculated by multiplying the consumption rate by the forecasted need or allocated maximum capacity in pieces and the failure rate. Note that downtime only affect consumption of production hours and not raw materials while defects affect both. This need is then summarized for all Product Groups per Resource Group and divided by the dedicated capacity of that Resource Group to determine the utilization, as shown below:

$$U_k = \frac{\sum_{l \in L} \frac{C_{kl} X_l}{F_{k,l}}}{D_k}$$

Where:

$$X_l = \begin{cases} N_l & \text{for utilization based on forecasted need} \\ E_l & \text{for utilization based on allocated maximum capacity.} \end{cases}$$

The failure rate is as follows:

$$F_{kl} = (1 + q_l)(1 - R_k)$$

Where R_k is the average defect rate for a Resource Group determined through a weighted average of the defect rates within that resource group based on their respective capacities:

$$R_k = \frac{\sum_{i \in I} (r_i d_i A_i)}{\sum_{i \in I} (d_i A_i)}$$

Determining Allocated Maximum Capacity

The allocation for the maximum capacity is based on the average forecasted need determined from the SPI. First the bottleneck Resource Group has to be determined for each Product Group by looking at the Resource Group with the highest utilization based on the average forecasted need for that Product Group.

The allocated maximum capacity is then the average forecasted need divided by that bottleneck utilization. The function is as follows:

$$E_l = \frac{N_l}{\max_k U_{k, X_l = N_l}}$$

If all Product Groups in a production line do not share the system bottleneck the resulting allocated maximum capacity will not be a maximum capacity as there will be exceptions. When this is the case an iterative procedure is used to maximize all bottlenecks:

Determine which Product Groups are below maximum capacity of their bottleneck Resource Group. The bottleneck's utilization is used, and is determined as follows:

$$\text{Bottleneck Utilization}_l = \max_k U_{k, X_l = E_l} Z_{kl}$$

Where Z_{kl} determines whether Resource Group k is used by Product Group l :

$$Z_{kl} = \begin{cases} 1 & \text{if } C_{kl} > 0 \\ 0 & \text{otherwise} \end{cases}$$

Increase the allocated maximum capacity by a common factor for these Product Groups until one of them acquires a bottleneck utilization of 100%. Remove this Product Group from consideration.

Repeat this step.

Appendix K – Template Instructions for Data Collection

Introduction and concept

For many years we have struggled to find a common way of defining and planning capacities within IKEA and in cooperation with our suppliers. For this reason, we have launched a project that will aim to improve the way of working, by establishing a common and agreed way to define, register and maintain supplier capacity in ONE framework. We will have clear roles and responsibilities, and the goal is that this will lead to a proactive and innovative way of solving potential capacity issues.

The process will in the long term also lead to a more even order pattern, a better overall utilization of the capacity for you and a simplified way of working in the relationship between us.

The base in the ONE Supplier Capacity process is Product Groups and Resource Groups.

Resource group (Defined by Trading Operations together with supplier)

Production resource/resources with similar characteristics constitutes a “Resource group”.

A Resource group provides capacity.

For example: Raw Material, Injection Machine, Paint line, Packaging

Product group (Defined by IoS together with Trading Operations/supplier)

Article/articles with similar characteristics AND share the same Resource group/groups constitutes a “Product group”.

A Product group consumes capacity.

IKEA Trading Office can supply a list with the Product Groups that your articles belong to.

Dedication (Defined by Trading Operations)

Dedicated Supplier Capacity is defined as the capacity that is dedicated to a given Resource group for IKEA for an agreed time period.

Allocation (Defined by Trading Operations)

Allocated Supplier Capacity is defined as the capacity that is allocated to a given Product group within a given Resource group.

In preparation for the coming visit, we'd like to ask you to prepare a mapping of your Resource Groups, and the Product Groups connected to them. You will find the Product groups defined for your articles in the separate Excel-sheet. On the following pages you will find instructions for the “Data Collection” template (Excel file attached). Please try to complete the Template before the agreed visit, so during the visit we can verify the table as well as begin with some capacity calculation exercises.

Data Collection

The “Data Collection” file is to be printed out and used to gather information from production. One is filled in for each Product Group (Excel file attached) for each production line.

Instructions:

Start by filling in the Product Group name at the top of the page and whether the calculation is performed for operational or tactical capacity.

For every unique resource in the production line enter the following in the corresponding columns as shown in the figure below. A unique resource is a resource or several resources that perform the exact same jobs with equal cycle times and contribute the same amount of pieces per cycle.

Nr	Unique resource (UR)	Amount of UR	Cycle Time (s) or Consumption (kg,pcs)	Pcs/cycle	Capacity* (per week dedicated to RPA)	Downtime (%)	Other Comments
1							
2							
3	1	2	3	4	5	6	7
4							
5							
6							
7							

Enter a name for that unique resource.
(for example “Handle Injection”)

Enter the amount of that resource.
(for example number of machines or number of laborers)

The cycle time or consumption rate.
(how long does it take to produce one batch of pieces in that machine or per laborer)

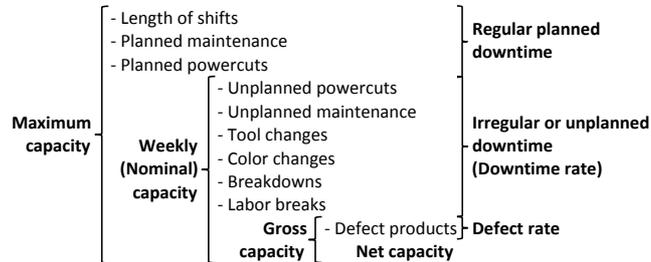
For raw materials or components the amount (in weight, volume or pieces) used per finished product should be entered.

Enter the number of finished products that the resource provides material for.
(for example if a tool has 10 cavities and each finished product needs 2 parts each, the pieces per cycle is 5)

Enter the capacity of each individual unique resource. This is the capacity that is planned to be used for production, taking into account regular planned downtime such as working hours and planned maintenance and powercuts.
(for example if there are three identical injection machines and they run at 138 hours each the capacity entered is 138)

Enter the downtime for each individual unique resource. This should include breakdowns and any other eventual stops in production for that unique resource not already taken into account for the dedicated capacity figure. This should include irregular downtime such as tool and color

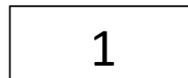
change, machine calibration, or unscheduled maintenance. The figure below depicts how to take planned and unplanned downtimes into consideration in the template.



Enter any additional information that can help you. This must include information about shared resources between different Product Groups and can also include things such as minimum order quantity for raw materials and whether labor is the constraint.

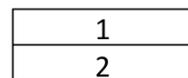
When this is finished the “Resource Group Layout” box should be used to draw up the Resource Groups that make up the production line. There are four different types of Resource Groups:

Type I: Resource Group with 1 unique resource



This is the simplest Resource Group when there is no grouping.

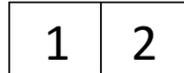
Type II: Resource Group with more than 1 consecutive unique resources grouped



If several unique resources perform different jobs but belong to the same Resource Groups.

Example:
 The Resource Group “Packing” can consist of several unique resources such as assembly, shrink-wrapping and packing)

Type III: Resource Group with more than 1 **parallel** unique resources grouped

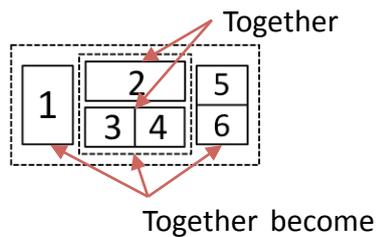


Several unique resources perform the same job but with different cycle times and/or produce different amount of pieces per cycle.

Example:

Injection machines with different cycle times and/or different amounts of cavities that make the same part)

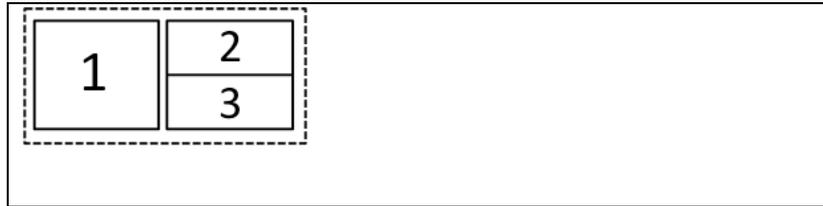
Type IV: A combination of **consecutive and parallel** groups grouped together



Group the three previous types by making a square around them. Several can be grouped as above. Here Nr 2 and the grouped Nr 3 and 4 become a Type II group. This new group along with Nr 1 and the grouped Nr 5 and 6 become a Type III group.

Example:

In injection molding if there are two machines that are automated differently. One makes the piece and trims off waste automatically (Nr 1) while the second machine (Nr 2) does not automatically trim. This machine has a laborer after it (Nr 3) who manually trims. Then the grouping would be performed as below:



Each Resource Group should also be given a name consisting of two parts. The first is a generic name where following are examples that should be used:

- Raw Material (RM)
- Injection Machine (IM)
- Support Machine (SM)
- Component
- Assembly
- Packing

The second is a specific identifying name. This can be a machine number or the Product Group and part.

Data Collection Example

After collecting the data from a production line (in this case for the Product Group Tolsby) the data collection should look like this:

Nr	Unique resource (UR)	Amount of UR	Cycle time (s) or Consumption (kg,pcs)	Pcs/cycle	Capacity* (per week dedicated to UR)	Downtime (%)	Other Comments	Resource Group Layout	
								Group	Layout
1	Raw Material	-	100g	-	50000	-	min. order quantity: 25 tons		
2	Injection frame 1	1	35	4	138	2,50%	8 cavities => 4 pieces	<pre> graph TD RM1[Raw Material 1] --> IF[Injection Frame] IF --> I2[2] IF --> I3[3] IF --> IFoot[Injection Foot] IFoot --> I4[4] IFoot --> I5[5] IF --> SM6[Support Machine 6] IFoot --> SM6 SM6 --> C8[Component 8] SM6 --> P7[Packing] P7 --> P9[9] P7 --> P10[10] P7 --> P11[11] </pre>	
3	Injection frame 2	3	30	2	138	2,00%	4 cavities => 2 pieces		
4	Injection foot 1	3	55	4	138	1,50%			
5	Injection foot 2	1	60	6	138	2,00%			
6	Stamping	2	3.5	2	138	3,50%			
7	Clipping	1	1	1	138	-	labor		
8	Component	-	1piece	-	500000	-			
9	Assembly	1	1	1	138	-	labor		
10	Shrink wrap	1	2	1	138	4,00%			
11	Packing	1	<1	1	138	-	labor		
12									
13									
14									
15									
16									
17									
18									

The different unique resources (injection machines) for making frames have been grouped as Type III groups as they perform the same jobs. The same is true for the making of the foot. The unique resources 7, 9, 10, and 11 have been grouped into a Type II group as they are all essentially a part of the packing line but don't perform the same job as one another.

Appendix L – Template Instructions for Data Analysis

Data Analysis

Using the data collected using the Data Collection paper you will be able to calculate the total capacity for the product with the Excel template called “Data Analysis”. Notice that it is only possible to edit the yellow fields in the tables. There is also a Tools sheet that will help transferring the figures from the Data Collection into the Data Analysis.

This is what the Excel sheet looks like and the individual parts are explained below it:

Product Group		Consumption rate	Consumption rate	Consumption rate	Consumption rate	Capacity	Shutdown
Resource Group	Unit	(unit/piece)	(unit/piece)	(unit/piece)	(unit/piece)	(unit/week)	rate (%)
2	3		4			5	6
Default rate (%)			7				
Average for 17 weeks from SPI, starting from the first week after the Lead time L			8				
Resource group needs based on average forecasted need from SPI							
Resource Group	Unit					Utilization with average need	
			9			10	11
Capacity Allocated by Need							
			12				
Overwrite Capacity							
			13				
Number of Pallets							
Percent to Increase capacity to reach bottleneck potential 17							
Resource group needs based on capacity allocation or overwrite capacity							
Resource Group	Unit					Utilization with registered Capacity Index	
			14			15	16

Product Groups

Start by entering the names of the Product Groups for a certain production line.

Resource Groups

Enter the names of the Resource Groups.

Units

Select the units that the capacity of the Resource Groups is measured in from the drop down lists. For machines and labor this is hours, for raw materials this can be for example kilograms, and for components this is pieces.

Consumption Rate

The consumption rate is the number of pieces that a resource group processes per unit (as previously determined). The following is usually true for machines and labor where the unit is hours:

Type I: For each machine the consumption rate is calculated from the cycle time using “Table Type I” in the “Tools” sheet.

Table Type I

Calculating Consumption Rate of One Unique Resources					
Unique resource	Amount of resource	Cycle Time (s)	Pieces/cycle	Capacity* (per UR per week)	Capacity (pieces/week)
Consumption Rate:					#DIV/0!
Total Capacity per week:					0

Type II: The Resource Group’s consumption rate is the consumption rate of the bottleneck unique resource. If the figures for all the unique resources of a Resource Group are entered into “Table Type II” the one with the lowest capacity in pieces per week is the bottleneck and is highlighted in red. The consumption rate and total weekly capacity for that one is shown at the bottom.

Table Type II

Determining Bottleneck and Calculating Consumption Rate of Consecutive Unique Resources					
Unique resource	Amount of resource	Cycle Time (s)	Pieces/cycle	Capacity* (per UR per week)	Capacity (pieces/week)
Consumption Rate:					#N/A
Total Capacity per week:					#N/A

Type III: Use “Table Type III” in the “Tools” sheet. Enter the figures for all the unique resources of a Resource Group and the average consumption rate is presented as well as total weekly capacity.

Results:

Need in chosen unit based on average need

The results tables show how much capacity of each Resource Group that each Product Group needs given the SPI average need.

Utilization based on average need

Shows the level of utilization of each Resource Group given the SPI average need.

Bottleneck utilization for each Product Group based on average need

This table identifies the utilization of the Resource Groups that each Product Group uses. From here the bottleneck Resource Group for each Resource Group is determined and highlighted. Note that this bottleneck may only be true given the average need and may change.

Capacity allocated by need

These are the final capacity values for the product groups where the capacity is allocated with regards to the SPI average needs. There is also the possibility to overwrite these figures here affecting the results in the tables explained in sections 14 to 16 below.

Capacity in pallets

To calculate the capacity in pallets enter the amount of pieces per pallet.

Need in chosen unit based on resulting capacity figures

The results tables show how much capacity of each Resource Group that each Product Group needs given the resulting capacity figures (capacity allocated by need or overwrite figures).

Utilization based on resulting capacity figures

Shows the level of utilization of each Resource Group given the resulting capacity figures.

Bottleneck utilization for each Product Group based on resulting capacity figures

This table again identifies the utilization of the Resource Groups that each Product Group uses and the bottleneck utilization is highlighted. Here the bottleneck may have moved. If the bottleneck utilization is not 100% for each product group, use the iterative procedure presented in the next section.

Common factor used for iterative procedure (if final bottleneck utilization is less than 100%)

If the final bottleneck utilization for one or more Product Groups is not 100%, use the following iterative procedure:

For these Product Groups only, in the overwrite capacity cells make a formula multiplying the capacity allocated by need for this Product Group by the common factor (start with the common factor at 100%).

0			
=M102*Q103		Percent to Increase capacity to reach bottleneck potential	100%
#DIV/0!			

Increase the common factor until one of these Product Groups achieves 100% utilization for one of its Resource Groups (as shown in section 16 above).

When a Product Group achieves 100% bottleneck utilization replace the formula in the overwrite field with the capacity that the formula gives.

Continue increasing and repeat steps 2 to 3 until all Product Groups have 100% bottleneck utilization.

Data Analysis Example

Product Groups

First we enter the Product Groups, and in this example it is only Tolsby.

Product Group:	Tolsby			
-----------------------	--------	--	--	--

Resource Groups

Here the Resource Groups from the Data Collection are entered:

Resource Group
Raw Material
Injection Frame
Injection Foot
Support Machine
Component
Packing

Unit

Next the units by which the Resource Groups are measured in is selected from the drop down lists:

Resource Group	Unit
Raw Material	kg
Injection Frame	hours
Injection Foot	hours
Support Machine	hours
Component	pieces
Packing	hours

Consumption rate

The first step here is to convert the cycle times and raw material and component consumption into the units that were selected above. For this the tables in the “Tools” sheet are used to help. The following shows how the consumption rates for each Resource Group are determined.

Raw Material:

For each finished Tolsby product 100g is needed, and this is converted into the selected unit kg (0.1kg).

Table Type I

Calculating Consumption Rate of One Unique Resources					
Unique resource	Amount of resource	Cycle Time (s)	Pieces/cycle	Capacity* (per UR per week)	Capacity (pieces/week)
6	2	3,5	2	138	567771,4286
Consumption Rate:					0,000486111
Total Capacity per week:					276

Component

Each finished frame consists of one component (the plastic sheet).

Packing

This is a Type II Resource Group and “Table Type II” is used to determine the bottleneck of this group in order to determine its consumption. Below we see that unique resource number 10 in this group (shrink wrap) is the bottleneck as it has the lowest weekly capacity. The consumption rate is shown for the bottleneck and represents the consumption rate of the Resource Group.

Table Type II

Determining Bottleneck and Calculating Consumption Rate of Consecutive Unique Resources					
Unique resource	Amount of resource	Cycle Time (s)	Pieces/cycle	Capacity* (per UR per week)	Capacity (pieces/week)
7	1	1	1	138	496800
9	1	1	1	138	496800
10	1	2	1	138	248400
11	1	1	1	138	496800
Consumption Rate:					0,000555556
Total Capacity per week:					138

Now all the consumption rates are inserted into the Capacity Calculation sheet. If there were other Product Groups sharing the production line then the same method would be used to determine their consumptions for each Resource Group.

Product Group:		Tolsby			
Resource Group	Unit	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)
Raw Material	kg	0,1			
Injection Frame	hours	0,003535354			
Injection Foot	hours	0,003492063			
Support Machine	hours	0,000486111			
Component	pieces	1			
Packing	hours	0,000555556			

Defect rate and downtime rate

The average defect rate per Product Group and the average downtime rate per Resource Group for Tolsby is entered. The average for the two Type III Resource Groups are calculated as follows:

Injection Frame

$$\text{Average Downtime} = \frac{(138 \cdot 0,025 + 3 \cdot 138 \cdot 0,02)}{4 \cdot 138} = 0,02125 = 2,125\%$$

Injection Base

$$\text{Average Downtime} = \frac{(3 \cdot 138 \cdot 0,015 + 138 \cdot 0,02)}{4 \cdot 138} = 0,01625 = 1,625\%$$

Product Group:		Tolsby				Capacity	
Resource Group	Unit	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	(Unit/week)	Downtime rate (%)
Raw Material	kg	0,1					
Injection Frame	hours	0,003535354					2,13%
Injection Foot	hours	0,003492063					1,63%
Support Machine	hours	0,000486111					3,50%
Component	pieces	1					
Packing	hours	0,000555556					4,00%
Defect rate (%)		0,10%					

Capacity

Now the weekly capacity for each Resource Group is determined and entered.

Raw Material: 50 tons (50000 Kg) per week dedicated to this production line

Injection Frame: 4 machines * 138 hours per week = 552 hours

Injection Foot: 4 machines * 138 hours per week = 552 hours

Support Machine: 1 machine * 138 hours per week = 138 hours

Component: 500000 components per week

Packing: (Determined by shrink wrap)

1 machine * 138 hours per week = 138 hours

Product Group:		Tolsby				Capacity	
Resource Group	Unit	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	(Unit/week)	Downtime rate (%)
Raw Material	kg	0,1				50000	
Injection Frame	hours	0,003535354				552	2,13%
Injection Foot	hours	0,003492063				552	1,63%
Support Machine	hours	0,000486111				138	3,50%
Component	pieces	1				500000	
Packing	hours	0,000555556				138	4,00%
Defect rate (%)		0,10%					

Average need

Finally the average need per week for the Product Group is entered calculated from the SPI according to the instructions.

Product Group:		Tolsby				Capacity	
Resource Group	Unit	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	Consumption rate (Unit/piece)	(Unit/week)	Downtime rate (%)
Raw Material	kg	0,1				50000	
Injection Frame	hours	0,003535354				552	2,13%
Injection Foot	hours	0,003492063				552	1,63%
Support Machine	hours	0,000486111				138	3,50%
Component	pieces	1				500000	
Packing	hours	0,000555556				138	4,00%
Defect rate (%)		0,10%					
Average for 17 weeks from SPI, starting from the first week after the Lead time+1		60000					

Resulting Resource Group needs and utilizations for the Product Group based on average need

The results are calculated by the program and shown in the tables below. We see the need of each Resource Group for Tolsby and that the bottleneck given the SPI average need is the Injection Frame Resource Group.

Resource group needs based on average forecasted need from SPI							
Resource Group	Unit	Tolsby				Utilization with average Need	Tolsby
Raw Material	kg / Week	6006,0	0,0	0,0	0,0	12,0%	12,0%
Injection Frame	hours / Week	212,3	0,0	0,0	0,0	38,3%	29,3%
Injection Foot	hours / Week	209,7	0,0	0,0	0,0	38,6%	38,6%
Support Machine	hours / Week	29,2	0,0	0,0	0,0	21,9%	21,9%
Component	pieces / Week	60060,0	0,0	0,0	0,0	12,0%	12,0%
Packing	hours / Week	33,4	0,0	0,0	0,0	25,2%	25,2%

Resulting capacity allocated by need

The next table shows the capacity for the Product Group Tolsby as 152667 pieces. If there were more Product Groups sharing the same line the capacity would be allocated according to the average need. In this example we enter that one pallet contains 300 pieces for Tolsby, meaning that the total capacity in pallets is 509.

Capacity Allocated by Need	152667	0	0	0
Override Capacity				
Pieces per Pallet	300			
Number of Pallets	509	#DIV/0!	#DIV/0!	#DIV/0!

Resulting Resource Group needs and utilizations for the Product Group based on resulting capacity

As we can see the utilization of the bottleneck Resource Group for Tolsby (Injection Frame) is 100% given the resulting capacity.

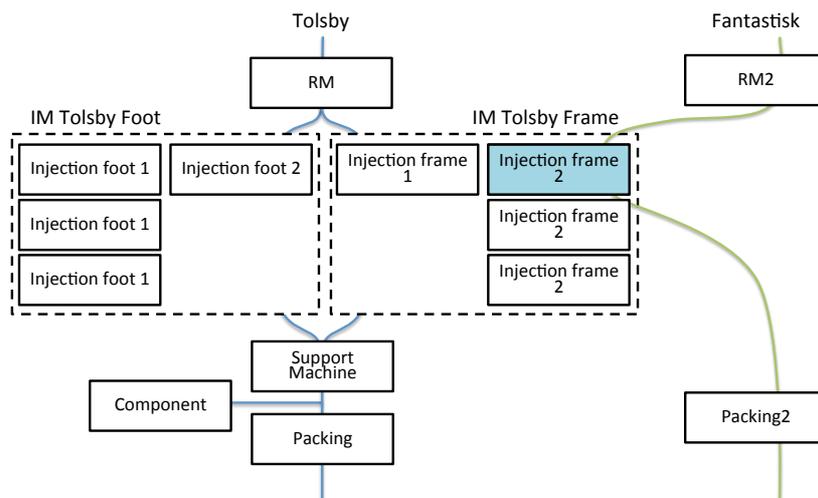
Resource group needs based on capacity allocation or overwrite capacity							
Resource Group	Unit	Tolsby				Utilization with registered Capacity value	Tolsby
Raw Material	kg / Week	15282,0	0,0	0,0	0,0	30,6%	30,6%
Injection Frame	hours / Week	540,3	0,0	0,0	0,0	100,0%	100,0%
Injection Foot	hours / Week	533,7	0,0	0,0	0,0	96,3%	96,3%
Support Machine	hours / Week	74,3	0,0	0,0	0,0	55,8%	55,8%
Component	pieces / Week	152819,7	0,0	0,0	0,0	30,6%	30,6%
Packing	hours / Week	64,9	0,0	0,0	0,0	64,1%	64,1%

Exceptions

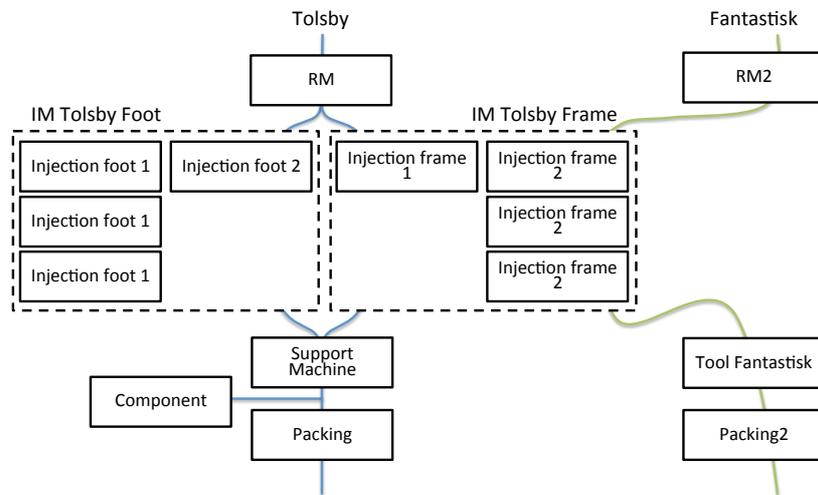
There may be circumstances where the method of using the Capacity Calculation Template is not straightforward due to complex productions.

Exception 1. Some but not all unique resources in a Type III Resource Group are shared.

The exception is illustrated in the following example where one of Tolsbys injection machines for frames is shared with another product Fantastisk.



In cases such as this it should be assumed in the template that Fantastisk can use the entire IM Tolsby Frame Resource Group. A separate Resource Group must then be created that constrains the capacity of Fantastisk so that it cannot use all injection machines in the Resource Group simultaneously. The new Resource Group should have the same downtime rate and the consumption rate for Fantastisk should be the same for both groups. In the case of plastic production the constraining factor limiting the use of an entire Resource Group is the amount of tools, and hence the new Resource Group created should be a tool group. This is shown in the following figure:



Exception 2. If one Resource Group is used more than once for a Product Group

If for example a Product Groups is worked in a machine and then later worked again in that machine, the consumption rate is the sum of the consumption rates of each of these two jobs.

Exception 3. If one Resource Group processes parts for several Product Groups simultaneously

If this is the case that Resource Group should be split into identical Resource Groups, one for each Product Group that uses it.