TAMPERE UNIVERSITY OF TECHNOLOGY

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IMPROVING THE MANAGEMENT OF GLOBAL MANUFACTURING RAMP-UPS

Master of Science Thesis

Examiner: Professor Paul H. Andersson

Examiner and topic approved in the Automation, Mechanical and Materials Engineering Faculty Council meeting on 5th of October 2011

ABSTRACT

TAMPERE UNIVERSITY OF TECHNOLOGY
Master's Degree Programme in Mechanical Engineering
ISOSAARI, LAURI: Improving the Management of Global Manufacturing Ramp-ups
Master of Science Thesis, 72 pages
March 2012
Major: Production Engineering, Mechanical Engineering
Examiner: Professor Paul H. Andersson
Keywords: Global ramp-up, global manufacturing, manufacturing start-up, new product introduction, production network, product transfer.

All trade becomes more international and the business environment is under constant change. The rapid global ramp-up of new products is becoming a more important success factor from the point of view of the entire product life cycle. The target of this study is to offer methods to improve a case company's global ramp-up procedures and to develop new practices to solve the most typical challenges in those projects.

The literature review presents the relevant theory concerning local and global ramp-ups. The main source of the theoretical information was literature covering the areas of new product introduction, project management and multi-cultural leadership. The field of study concerning the ramp-ups is relatively young, but offers a moderate amount of practices and examples. The field of global ramp-ups on the other hand cannot yet afford much, but is under growing interest of researchers.

This is a case study whose research subject is a multinational corporation of electrical engineering. The ramp-up practices and procedures used by the company have been studied using interviews, internal documents and a questionnaire sent to the employees with ramp-up experience. The objective was to find methods to develop the company's current global ramp-up model with the help of own observations and solutions offered by the literature.

The disturbances and challenges mentioned in the literature review correspond well with the observations concerning the company's earlier projects. Only the mutual weighting is different. Meanwhile the theoretical solutions cannot be seen to be perfectly suitable for the company. This is due to the industry specific suggestions, special characteristics of the factories and major benefits resulting from local adaptation. It was detected that during a global ramp-up there is a strong need for transferring knowledge and information between the different factories. The literature concerning global manufacturing ramp-ups should underline the observed management related aspects much better.

The recommendations for the case company focus on solutions to improve cooperation between the projects, methods to improve international relationships and a suggestion to develop a standardized start-up process for the international projects.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO
Konetekniikan koulutusohjelma
ISOSAARI, LAURI: Globaalin Tuotesiirtoprosessin Kehittäminen
Diplomityö, 72 sivua
Maaliskuu 2012
Pääaine: Tuotantotekniikka, Koneteollisuuden tuotantotekniikka
Tarkastaja: Professori Paul H. Andersson
Avainsanat: Globaali ramp-up, kansainvälinen tuotesiirto, tuotannonaloitus, tuotantoverkosto.

Yritysten liiketoiminnan kansainvälistyessä ja toimintaympäristön muuttuessa tuotannon nopea ylösajo muodostuu kriittiseksi menestystekijäksi tuotteen koko elinkaaren näkökulmasta. Tämän tutkimuksen tavoitteena on tarjota keinoja globaalin ylösajoprosessin kehittämiseksi. Lisäksi pyritään selvittämään ja ratkaisemaan tuotesiirtoprojektien tyypillisimmät haasteet ja tarjoamaan uusia vaihtoehtoisia käytäntöjä tiedon ja tietämyksen siirtoon tuotantoverkoston sisällä.

Tutkimuksen kirjallisuuskatsauksessa on esitelty sekä lokaaliin että globaaliin ylösajoprosessiin liittyvää teoriaa. Lähdeaineistona on käytetty tuotekehitystä, projektijohtamista ja monikulttuurisuutta käsittelevää kirjallisuutta. Lokaali ylösajoprosessi on tutkimusalana edelleen nuori, mutta tarjoaa kohtuullisesti esimerkkejä ja vaihtoehtoisia teoreettisia malleja. Globaalin prosessin tutkimus sen sijaan on alueena uusi, mutta kasvavan kiinnostuksen kohteena.

Tämä diplomityö on toteutettu tapaustutkimuksena, ja tutkimuskohteena toimii usealla eri mantereella toimiva monikansallinen sähköteknisen alan yritys. Globaaliin ylösajoprosessiin liittyviä yrityskohtaisia käytäntöjä on tutkittu haastatteluiden ja sisäisten dokumenttien avulla. Lisäksi toteutettiin kansainvälinen kysely aikaisemmissa tuotesiirtoprojekteissa mukana olleille henkilöille. Yrityksestä tehtyjen havaintojen ja kirjallisuuden tarjoamien mallien avulla pyrittiin hakemaan keinoja globaalin ylösajoprosessin kehittämiseksi.

Kirjallisuudessa esitetyt ongelmat vastasivat hyvin yrityksen haasteita, vaikkakin niiden keskinäisessä painotuksessa oli eroja. Kirjallisuuden menetelmät näiden haasteiden ratkaisemiseksi eivät kuitenkaan olleet kaikilta osin käyttökelpoisia. Tämä johtuu suositusten voimakkaasta toimiala-sidonnaisuudesta sekä yrityksen tarpeesta lokalisoida prosesseja paikallisten vahvuuksien hyödyntämiseksi. Tärkein havainto oli ylösajoon liittyvä voimakas tarve tiedon ja tietämyksen siirtoon tehtaiden väillä. Alan kirjallisuuden tulisikin siten huomioida johtamisnäkökulma nykyistä paremmin.

Toimenpidesuosituksina esitetään tapoja kehittää tuotesiirtoprojektien välistä integraatiota, kansainvälisen vuorovaikutuksen lisäämistä eri menetelmillä sekä käytäntöjä kansainvälisten projektien aloitukseen liittyen.

PREFACE

The subject was offered and the thesis was made possible by the product group of Low Power AC of ABB LV Drives. The research was made for the Department of Production Engineering at the Tampere University of Technology. The examiner was Professor Paul H. Andersson and the supervisor at ABB was M.Sc. Mira Melin.

First I want to give my greatest compliments for my supervisor Mira for her endless support and advice during the research process. I also want thank the director of production Mr. Mika Vartiainen for offering this very interesting and educational opportunity to write this thesis for ABB and Professor Andersson for guiding me through this project.

The employees at ABB LV Drives have been a major help during this thesis. Especially the people involved in the production development both in the product groups of High Power AC and Low Power AC offered me indispensable knowledge about their experiences and advice on how to continue further. The interviews and the questionnaire answers were a very important part of the success of this project. Thank you all for offering your valuable time for this study.

My family and the important people around me have been a critical support during the 6 months. Many thanks for celebrating during the victories and supporting during the challenges. I want to give special thanks for my brother Markus for pushing me towards the goal and for offering his time for the suggestions and corrections.

I hope this thesis offers ideas and new solutions not only for the case company but also for other businesses considering similar issues.

Tampere, 6.3.2012

Lauri Isosaari

TABLE OF CONTENTS

ABBREVIATIONS AND TERMS

AC	Alternating current
BU	Business Unit
DC	Direct current
ERP	Enterprise Resource Planning
FPY	First Pass Yield
IS	Information System1
LS	Lead Site
NPI	New Product Introduction
OTD	On Time Delivery
PCT	Program Core Team
PDM	Product Data Management
PG	Product Group
PLM	Product Life cycle Management
PMO	Program Management Office
PSO	Program Support Organization
PWBS	Program Work Break Structure
R&D	Research and Development
SOP	Sales and Operations Planning
SOP	Start of Production
WIP	Work In Progress

1 INTRODUCTION

This thesis is made to discover the biggest targets of improvements in a case company's global ramp-up process and to recommend practices and solutions for those matters. The target is to improve the critical procedures and to assure the success in the coming ramp-up challenges.

Literature review is done from both local and global aspect to find new alternatives and practices for the process. The theory of ramp-ups has not been the subject of much research until the year 2000. Since then the field of study has slowly developed and the amount of information available today is relatively reasonable. Ramp-up in the literature typically means starting up an entirely new factory or production line possibly with new products. Delayed projects consume resources, are expensive and shorten the most profitable selling period. Ramp-ups should therefore be fast, controlled and avoid unexpected deviations from the plan.

1.1 Background

ABB LV Drives Low Power AC develops and manufactures electrical variable speed drives. The company does most of the product development in Finland, but manufactures the products globally in product family specific production lines. The products can be divided into five product families of which each is a variation of sizes and constructions. The line production is possible, because of the large amount of manual assembly processes and the manufacturing strategy to concentrate on assembly and logistics while outsourcing the part and module production. Although the typical product life cycle is from five to ten years, the amount of sites and products lead to the fact that the company is constantly facing ramp-ups at some of its factories.

During the past ten years the company has grown and expanded its production to new sites and countries. It has become a global company and the benefits of scale are now available. Until the recent years, the new international factories have ramped up their production processes relatively independently, and not much attention has been paid to the global coordination and integration. The future challenges are a bit different as the upcoming international ramp-ups are more product transfer related and take place in stable environments with qualified employees. The case company is currently developing methods to organize the transfers, and therefore the meaning of this thesis is to offer future visions and valuable information to support this work.

1.2 The research problem and objectives

The main target of this thesis is to answer to the research question: *How to improve the management of global manufacturing ramp-ups?* The overall objective therefore is to find methods to improve the management and execution of international product transfers and ramp-ups in global multiple site production networks. The research problem can be divided into three key objectives.

- The first target is to collect opinions from the regional factories about their needs during the ramp-ups. This is studied using a questionnaire form.
- Other mission is to find the biggest problems in the network during the ramp-up situation and study different solutions to solve these issues.
- The third objective is to recommend methods to improve the transfer of knowledge and information inside the manufacturing network.

The vision of a successful global ramp-up could be that every following ramp-up is faster and more efficient than the earlier saving time and money. The practices are shared and developed further in the following factories and eventually fluently transferred and implemented back into the earlier sites.

1.3 Limitations

The field of study is wide and some research limitations need to be made. The thesis is limited to concern the case company’s two product families that are currently facing or waiting for the start-up of a global ramp-up project.

Topics concerning sourcing and logistics such as quality and supplier verifications are not discussed. R&D (research and development) issues are not studied with the exception of subjects closely tied to the manufacturing ramp-ups.

1.4 Research methods

The literature review presents the relevant frameworks and theories. The main sources of information are research papers available in the Internet and books related to project management and new product introduction process. The current processes in the case company are analyzed using interviews and internal documents.

The key method to acquire information from the regional factories was a short inquiry that consisted of seven questions. The initial target was to have live interviews both with the people in Helsinki and in the regional sites. Unfortunately the plan turned out to be too challenging, although these discussions would have been very important and useful. No recent ramp-up data was available so there was no possibility for the otherwise useful quantitative analysis.

1.5 The structure of the thesis

The thesis consists of five chapters and the structure follows a typical pattern used in research. The first is introduction and offers general information about this study.

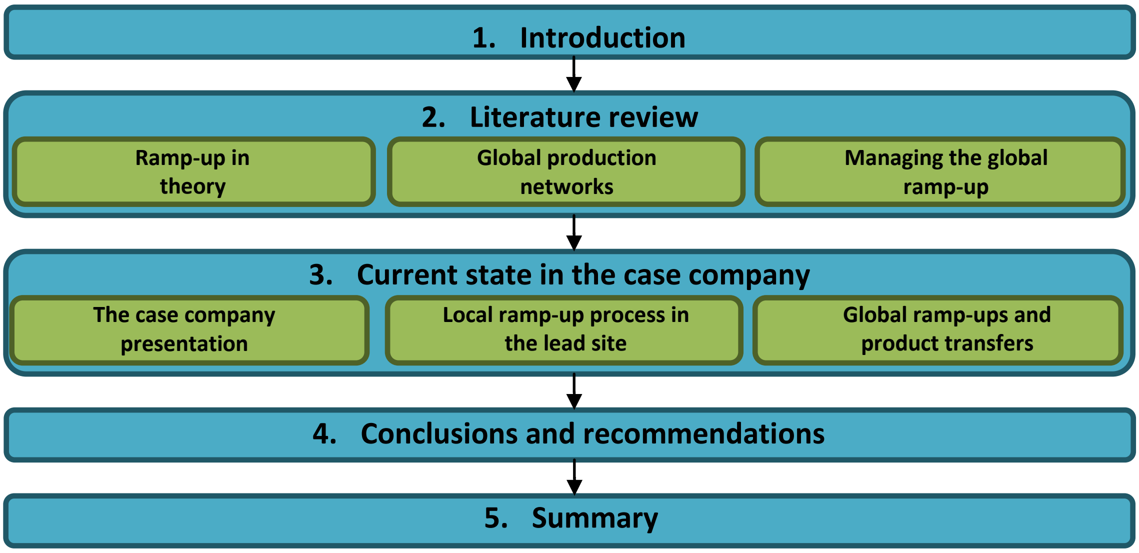

Image 1.1. *The structure of this thesis.*

After the chapter of introduction the findings in literature are presented. The aim of the literature review is to create a basis for the case studies. Another objective is to find good practices and alternatives for the ramp-up processes. The chapter is divided into three sections, the first of which is about ramp-ups in general. The second presents the idea of global production networks while the third is about global ramp-ups.

Chapter three presents the case company more specifically and describes the current state of both local and global ramp-ups in the company. The target is to give a general overview of how things are done and similarly point out the noticed challenges in the process. The information is gathered using interviews, inquiries and internal documents.

The next chapter number four presents the observed challenges and offers alternative solutions to solve these noticed issues. The thesis ends with the final summary in the chapter five.

2 LITERATURE REVIEW

This chapter presents the findings in the literature concerning local and global ramp-ups and describes the purpose and benefits of global production and production networks. The review is based on findings in the literature related to the ramp-up situation. The objective is to give a theoretical overview about the issues discussed in the later chapters. Another goal is to offer visual frameworks for the case company to facilitate general communication.

2.1 Ramp-up in theory

Product life cycles get shorter and the profit window becomes narrower. To fix this the companies need to increase new product introduction frequency and start profitable production rapidly. Well managed ramp-ups are a key solution to make these things possible.

One way to understand the definition of ramp-up is to describe it as the final part of the new product introduction process. The phase is faced every time a new product is introduced or a new production line is built. (Bellgran & Säfsten 2010, p. 277.) It is also important to understand, that the ramp-up is not only the following phase after product development but also an interface between production and market launch. The mastery of connecting these two parts is becoming a crucial success factor for manufacturing companies. (Winkler et al. 2007, pp. 103-110.)

Ramp-up can also be described as a project that lasts for a certain period and has various objectives. Especially the management is very project related and the employees are often organized in virtual and self-managed project teams. Therefore there is a strong need for knowledge management and coordination. What makes it different from typical projects is that there are elements that need to be done or considered far in advance. Plenty of issues have also been decided before the project begins such as product design and various limitations. (Gross & Renner 2010.)

Ramp-up is a very cost intensive and critical part of the product life cycle. Numerous unforeseen problems have to be solved and therefore the process is rarely stable and predictable. The target could be a quick implementation of a robust production system where disturbances are avoided and the problems are solved fast and independently by the manufacturing system.

An often forgotten issue is that ramp-ups should be finished rapidly because they consume plenty of extra resources such as work and machine time. After the project is finished the people and resources can move further to next projects and continue the work there. There might also be a need for overcapacity in other factories which causes costs and requires extra capital. (Bellgran & Säfsten 2010, pp. 231-245.)

2.1.1 Ramp-up in general

Typical reasons to change the assembly system are the introductions of new or matured products. Therefore product and process engineering are often closely related. Ramp-up typically leads to a struggle with the design issues and weak production productivity. This is something that is part of every manufacturing company's operations at some point. (Bellgran & Säfsten 2010.)

Graphical charts are very important when ramp-ups are described. Ramp-up and learning curves are the most typical methods to portray the improvement. Ramp-up curve is typically used to present the acceleration of volume. The shape and angle of the curve depend on the capabilities of the company and the complexity of the ramp-up (Clark & Fujimoto 1991, pp. 192-193).

Learning curve on the other hand describes the development of knowledge and skills. It can be seen from the point of view of individual, group or organization. As workers have more experience and understand the product better, the indicators such as quality and productivity should improve. (Almgren 2000, pp. 4579-4585.)

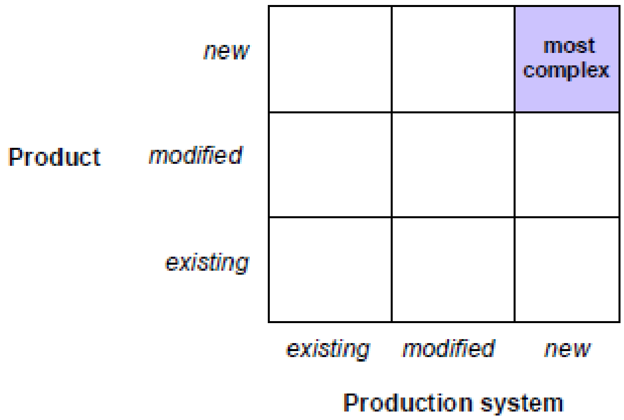

Image 2.1. *The complexity of the situations (Bellgran & Säfsten 2010, p. 231).*

It is important to make a difference between the start-up situations of a new and a developed product. The previous manufacturing line is typically used as a foundation for the new implemented solution. That makes the ramp-up a bit less complex. In case of an entirely new product and production system no experience or knowledge is available and the situation is completely different compared to a developed product in an existing production system. (Bellgran & Säfsten 2010, pp. 231-236.)

Conflicts have a big role in NPI (New Product Introduction) and ramp-up processes. It is natural that objectives and constraints in the organization vary and every decision has an effect on the work of a colleague. There are two interfaces where the conflicts are the most typical. Product and process engineers have difficulties with each other because the R&D people would like to improve the product while the process engineer would prefer to freeze the design and order the equipment as fast as possible. Another challenging interface is the one with production and sales functions. The first faces constant engineering changes and new problems while the sales department demands for the exact date when to start the sales and the amount of products available to promise. There are not many tools that would help other than open and flexible cross-functional communication. (Clark & Fujimoto 1991, p. 124.)

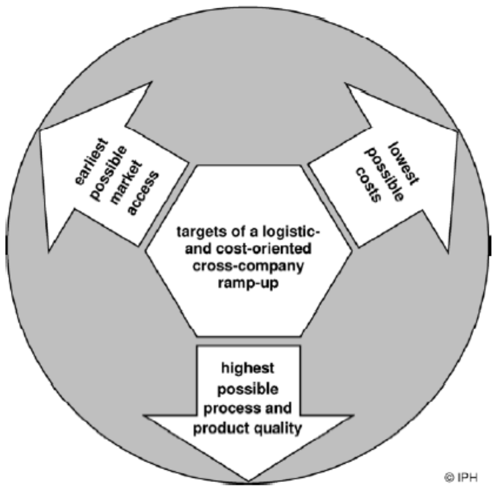

Image 2.2. *Typical reasons for conflicts (Hüntelmann et al. 2007, p. 116).*

Engineering changes, such as changes in drawings or in parts, can be described more as a rule than exception during ramp-ups. It is obvious that the design of complex products contains mistakes and later improvements. Fact is that it would be too expensive and slow to avoid all possible later changes although they are a major reason for cost overruns and delays in production ramp-ups. It is typical that still during the final run-up various engineering changes occur although the design should have been frozen long before.

European and U.S. manufacturing companies typically begin the pilot and ramp-up phases before the design is ready. There are different traditions to handle the modifications and the choice has a strong impact on speeding up the problem solving. First method is to handle the changes with a negative attitude and bureaucracy. In the other philosophy the changes are made flexibly, early and entirely by the person responsible for the change. In this latter Japanese method a design improvement is typically made if it adds value to the product. (Clark & Fujimoto 1991, p. 121.)

Prototypes are the key method to avoid engineering changes and they are a critical part of the ramp-up process. It is important to notice that there are two kinds of them. Early prototypes in designing phase aim at validating the products appropriateness for the market. The later production prototypes are more important from the view of ramp-ups. They are produced to develop the product and the production processes together to enable better manufacturability. (Bellgran & Säfsten 2010, p. 233; Clark & Fujimoto 1991, p. 120.)

There are two methods to produce the production prototypes. The first style used by the European high-end companies is to produce the prototypes from high quality materials by prototype specialists. The other method is used especially by the Japanese companies. The prototypes are built from parts dispatched by the regular suppliers and the product is assembled by normal workers. This enables better feedback and a realistic perceiption of the quality. (Clark & Fujimoto 1991, p. 120.)

Pilot-runs can be described as simulations or rehearsals of real production using real tooling and equipment. The phase can also be called as pre-production phase. The idea is to test the entire production system and reveal design errors and problems that were undetected during the prototype phase. The work continues during the later production ramp-up period. It is important trying to find the design problems before the real high volume production starts.

Pilot runs can be done in a separate site, separate pilot line or even on volume production lines concurrently with the current production. The latter gives the most realistic simulation but also causes the biggest disturbances. Typically the tooling is not ready yet so it can be a mixture of prototype and serial equipment. The pilot production cycle times are also normally much slower than during the serial production. Pilot production typically consists of a certain amount of runs and the entire system is improved during these events. (Clark & Fujimoto 1991, p. 175.)

Bellgran and Säfsten (2010, pp. 234-235) use the term SOP (start of production) to indicate the point since when the products are supplied to customers. Clark and Fujimoto (1991, p. 122) specify that start of production is typically located a few months before the product is released to sales. That is because the pipelines of the supply chain need to be filled to respond to the demand immediately. The releasing date can also be regarded as the real and final deadline to have the product and the production ready.

2.1.2 Alternative frameworks

The ramp-up terminology is not entirely unified and therefore three alternative frameworks are presented. Almgren was one of the first to publish a detailed model. His research is very focused on auto industry. He uses the term final verification that includes both pilot production and manufacturing start-up. Pilot production refers to a phase where pilot runs are done in the system that is implemented in the site before commercial use. The following start-up phase is divided into low and high volume production phases. Ramp-up is signifies only the phase where the production volume is rapidly increased. However, if there is no need for extra training or fine tuning of product or production system, the phase of low rate production can be ignored and the ramp-up to high volumes can start immediately. (Almgren 2000, p. 4580.)

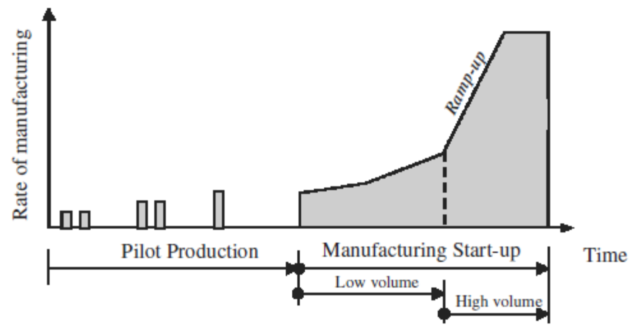

Image 2.3. *Almgrens framework (Almgren 2000, p. 4580).*

Bellgran and Säfsten have a bit different perspective. After the product and process designs are ready, it is time to carry out production system realization and production start-up planning. These are advised to be done concurrently. During the following pre-series production phase the personnel is trained and the system verified. Here the term start-up includes all the activities that are realized since the equipment and machinery exist until the system is passed further for the maintaining functional organization. Ramp-up is just the concluding phase where the production volume and quality are increased to reach the targets. Ramp-up can also be carried out before the start of production if necessary. (Bellgran & Säfsten 2010, pp. 231-239.)

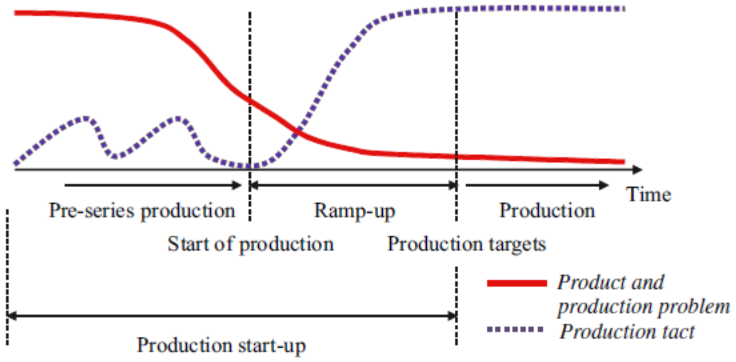

Image 2.4. *Alternative start-up model (Bellgran & Säfsten 2010, p. 235).*

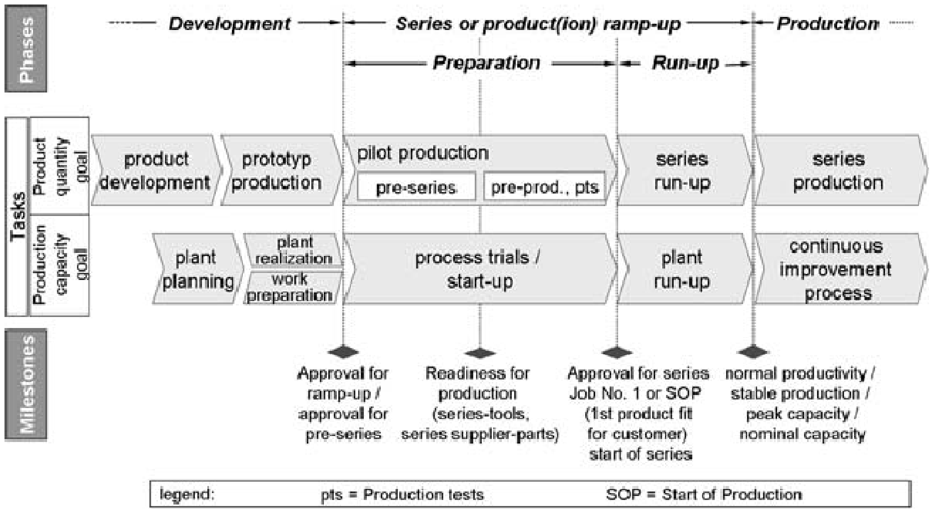

Image 2.5. *The latest ramp-up framwork (Heins et al. 2006).*

Image 2.5 presents the third framework which is described to be the most popular approach during the time the research paper was published in 2007. In this model the entire earlier start-up phase is now called production ramp-up. The idea of this framework is to eventually connect the developed product and the built capacity and increase the utilization rate to 100 %. The development of these two objectives can be seen separate. (Winkler et al. 2007, pp. 104-106).

The ramp-up phase is divided into preparation and run-up. The framework's idea is to design the product and construct the production environment as ready as possible before the preparation begins. During the ramp-up the product and the production system face small modifications and adjustments to make the production process flow and achieve the targets set for the entire system. (Winkler et al. 2007, p. 105.)

The preparation phase consists of production start-up and pilot production. Start-up means that the plant or just the line is developed step-by-step to start the real production. The processes and the equipment are modified to produce the designed product. Pre-series pilot production means manufacturing of higher amounts of prototypes while testing the necessary processes. The following pre-production phase means training of the workers and fine tuning of the system. It is important that during the pre-production phase the parts are sourced from the final suppliers and the production takes place with the series equipment used in the final manufacturing system. (Winkler et al. 2007, p. 105.)

Production run-up is the next part of the ramp-up. It also means the start of production. The operations needed in this phase concentrate on increasing the produced volume and are such as detailed training and improving the logistics and organization. (Winkler et al. 2007, p. 105.)

2.1.3 Different ramp-up curves

There are three strategies to proceed from the existing production to a new manufacturing system. The image 2.6 illustrates the differences. Grey represents the old and black represents the new product. The alternative (a) means closing down the production and starting from scratch which is common in Europe and in the USA. The alternatives (b) and (c) portray mixed model methods, common in Japanese companies with unchanged production systems. The methods require more efforts on coordination, supply of materials and work tasks. The idea of the mixed model is to reduce losses in capacity during the transition. (Bellgran & Säfsten 2010, p. 240.)

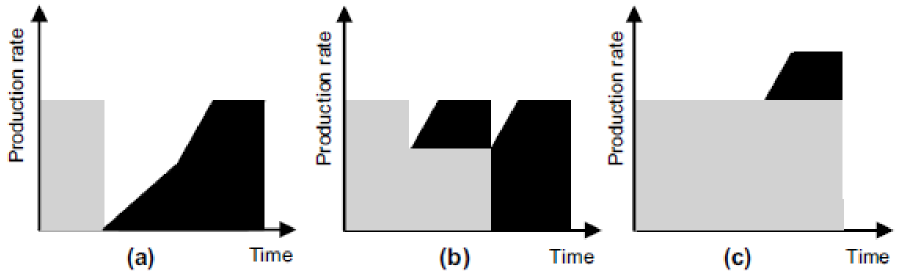

Image 2.6. *How to proceed to volume production (Bellgran & Säfsten 2010, p. 240).*

Another noticeable strategic issue in the image 2.6 is the angle and slope of the curve. It is generally recognized that the most effective method to ramp-up production is to reach full production rate as soon as possible. However it is not just a question of choice. It also depends on the resources and abilities in the company. Almgren suggests that the line should be driven with full speed or not at all to help the personnel to create right norms concerning the production. It also helps allocating the right amount of resources and finding problems and disturbances from the processes. The third benefit is the better and faster learning at the beginning of the learning curve. (Almgren 2000, p. 4587.)

It is also possible to optimize the amount of workforce. The image 2.7 demonstrates the options. The alternative (a) presents the influence on the workforce caused by the close down method. However the requirement of this theory is that the workforce should be variable. The alternatives (b) and (c) represent the impacts of the mixed models. (Bellgran & Säfsten 2010, pp. 241-242.)

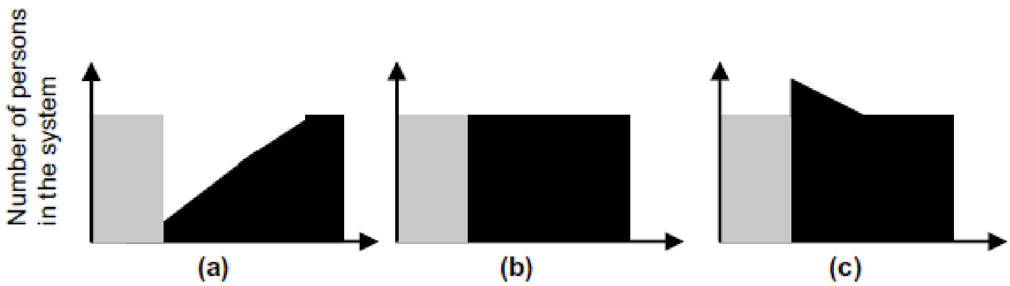

Image 2.7. *Different ramp-up workforce policies (Clark & Fujimoto 1991, p. 193).*

Typically there has been made a choice between starting with high volume or high margin products. The latter method normally leads into moderate volume increase. Three strategies for the high margin variant ramp-up is presented in the image 2.8.

- *Slow Motion* means that all products are ramped up concurrently, which leads into a slow start while the volumes rise faster towards the end. This is suitable if the system is very automatic or if the old and new products overlap.
- *Dedication strategy* symbolizes sequential introduction of products into production. New variants are ramped-up only after the assembly of the earlier is completely learned. This is designed for companies focusing on assembly operations with high quality requirements.
- The third *Step-by-Step* option means that after starting the production, the processes are sequentially and separately improved. This is suitable if the ramp-up situation is very complex. (Bramley et al. 2005, *p.263*).

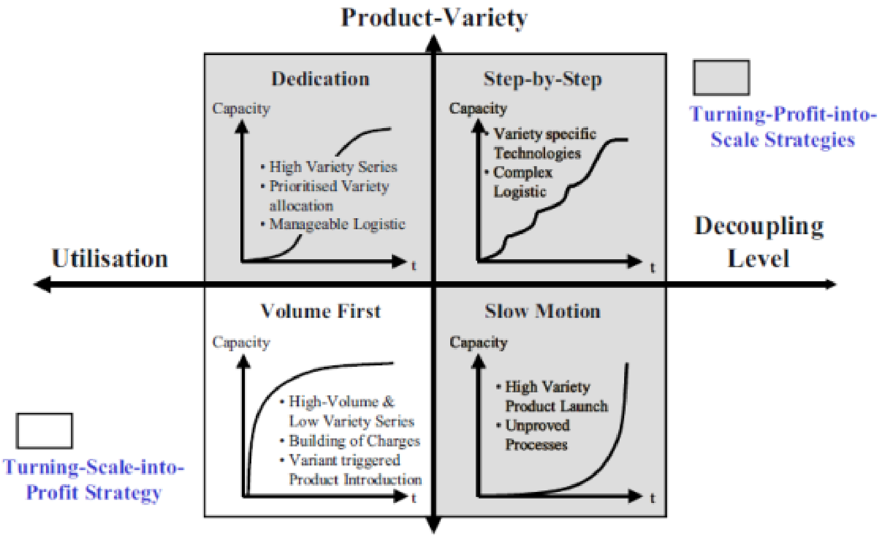

Image 2.8. *The alternative ramp-up curves (Bramley et al. 2005, p.263).*

Finally the question about the allocated resources can also be seen as strategic. Bellgran and Säfsten underline the question concerning the amount of money still financially justifiable to be invested in a ramp-up. An interesting alternative is to encourage the organization to train people thoroughly and prepare the production system well with sufficient resources to avoid the disturbances. (Bellgran & Säfsten 2010, p. 244.)

If it is so expensive to fail and be late, how much money should be used? The research does not give direct answer but according to earlier studies it is more expensive to be late than consume 50 % more money in an on time ramp-up project. Almgren (2000, p. 4578) also states that disturbances during the start-up or in the volume curve can cause major losses in the entire life cycle revenue.

2.1.4 Information exchange during a ramp-up

Insufficient cooperation and information exchange are often listed as key reasons for failures and disturbances during ramp-up projects. There is a strong need for tools and structures that help and force the people and functions involved to communicate.

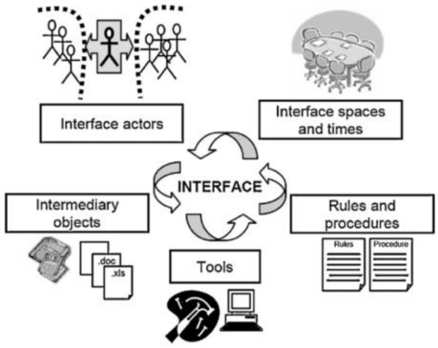

Image 2.9. *The five elements of information exchange* (Surbier et al. 2010).

The communication processes consist of five elements. A theoretical approach can be useful when the transfer of information is being developed. (Surbier et al. 2010)

- Interface Actors: The stakeholders of this interface.
- Interface spaces and times: Signifies the place and time for communication.
- Intermediary objects: Means the type of information that is being transferred.
- Tools: Methods to exchange information such as MS Office, ERP (Enterprise Resource Planning) and PLM (Product Life cycle Management) systems.
- Rules and Procedures: A helpful practice to assure the flow of information is to document the interface with describing the rules, needs and participants.

The information concerning the disturbances can be categorized into problem, domain and problem solving information. Problem information consists of details and data related to the occurred event. Domain information means overall information about the process and event such as facts and theories. The last form signifies knowledge of overall methods for problem solving. (Fjällström et al. 2009.)

The experts in organizations are those who often solve the problems. They have the facts, know the procedures and have a long work experience.The experts do problem solving typically with domain information while the less experienced employees prefer problem information. Training is one method to offer this knowledge for the employees with shorter work history. The right source of information depends on the people and problem. The preferred source is typically other people, except with product information where the documents are more preferred. A method to increase the information available is to establish people networks with internal and external participants. (Fjällström et al. 2009.)

2.1.5 Management and organization structures

The literature typically regards the management related matters such as management involvement, people commitment and planning as key factors for the ramp-up success. The management should not only be involved but also support and push to achieve better results. Other important elements are the project management procedures meaning planning, organizing and controlling the tasks and the flow of information. There is also a need for a company-wide ramp-up strategy which should offer standardized processes and define the pursued targets. (Gross et al. 2010.)

Bellgran and Säfsten suggest nominating a person such as a ramp-up manager who is in charge of the entire project and makes sure that the plan is followed and targets are reached. The manager should be a person who has a comprehensive understanding and knowledge about production. If the company faces constant ramp-ups a permanent organization should be considered. (Bellgran & Säfsten 2010, p. 243.)

Production ramp-up period is often called wartime. That describes the need for informal procedures. The situations require efficient and flexible decision making for which the regular structures are too formal, slow and inefficient. (Almgren 2000.) To solve this it is typical to establish temporary cross-functional ramp-up teams. The cross-functionality should expand the group's domain information database and offer more and improved ideas. This should help problem solving and improve communication and coordination. (Fjällström et al. 2009.) The idea is to solve the problems immediately, not to transfer the decisions higher up in the organization. The teams might include blue collar workers because of their ability to give ideas and point out problems others do not notice. (Bellgran & Säfsten 2010, p. 243.)

Clark and Wheelwright present four alternative structures for the temporary teams that differ in the level of authority and independence. The more power the group has, the more capable it is to make decisions and deliver results. Full-time teams are not realism for every company. They are possible only if the organization has capable resources available, which is normally not realistic for the smaller companies. (Clark and Wheelwright 1992.)

Table 2.1. *Alternative project team structures (Clark and Wheelwright 1992).*

Team structure	Team leader	Manager's organizational authority	Members report and answer
Functional	Functional Manager	Over the group members	Functional manager
Light weight	Part-time Junior level	Coordination rights only	Functional manager
Heavy weight	Full-time Senior level	Accross different functions	Project manager
Autonomous	Full-time Senior level	Autonomous	Project manager

2.1.6 Ramp-up costs

The operational costs cannot typically be capitalized so they have a direct impact on the period’s profitability (Abele et al. 2008, p. 96). Sometimes it can be laborious to recognize the expenses caused by a single project. Some costs realize as project expenses while the others take place in the functional organization.

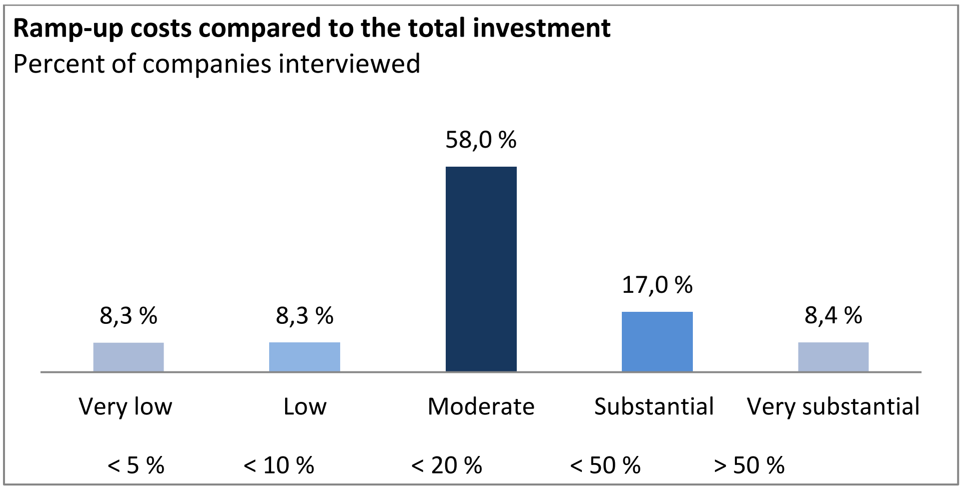

Figure 2.1. *The average ramp-up expenditures (Abele et al. 2008, p. 97).*

The situations and industries are different so it is difficult to estimate precise generic cost structures. However Abele et al. (2008, p. 97) offer interesting information about the average costs of a manufacturing ramp-up when a new factory is established. Typical project expenditure is just above 20 % of the total investment containing the buildings, plant and equipment. The expenditure does not differ much between the geographic locations.

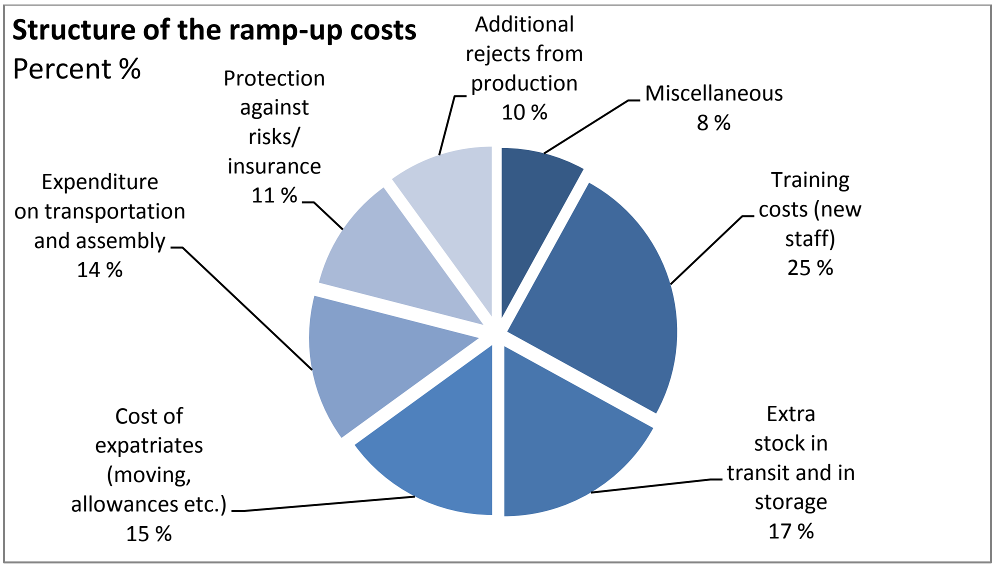

Figure 2.2. *The structure of average ramp up costs (Abele et al. 2008, p. 96).*

The costs consist of various sources. Figure 2.2 gives an average cost structure when roughly 20 % of the total new factory investment is allocated to the ramp-up. The biggest shares are explained more detailed according to Abele et al. (2008, p. 97).

- Training expenses form the biggest share. It can happen in the lead site or at the regional factory by an expatriate, visiting employees or local trainer.
- Excess inventory is needed to maintain service levels during lover production rate and delays. The stock is made with extra hours or additional capacity.
- Expatriates can be necessary to improve cooperation and communication. The expenses are high because of training and compensations for the family.
- Transportation of the equipment, tools and materials to distant countries cause big costs because of packing, loading and setups with testing.
- Additional expenses can be miscellaneous. Some examples are the insufficient production quality and the testing and approval procedures.

2.1.7 Typical disturbances and problems

Ramp-up can be described as a period of problems and confusion. It is typical that the productivity collapses due to the chaos caused by jumping defect and scrap rates. It is obvious that there is a connection between the ramp-up speed and confusion. The amount of problems the organization has to face simultaneously simply increases along with the faster clock frequency. (Clark & Fujimoto 1991, p. 198.) Despite of the lack of time and resources the problems during ramp-up should never be underestimated. The instant solving is crucial and comments such as “that can be corrected later” should be avoided. (Bellgran & Säfsten 2010, pp. 245-247.)

The amount of problems during a ramp-up depends on the readiness of the product and production system. However it should be remembered that ramp-ups are not just about designing and building production systems. They also contain and demand continuous learning throughout the organization. Although the problem solving causes costs and consumes time, it is a necessary activity for the system to develop. It is also the best way to make people learn the new product and processes.

Some of the most common problems are the late engineering changes taking place during the piloting or ramp-up phases as mentioned earlier. A suggested solution is to add manufacturing engineers in the product development process and vice versa by rotating tasks and responsibilities to reduce design inconsistencies. The organization should also focus on identifying the possible sources of disturbances as early as possible during the pilot production. (Almgren 2000, pp. 4577-4579.) A third possibility is to add guest engineers from the suppliers to the factory floor to improve the mutual problem solving during most hectic periods.

Disturbances and problem solving can have two general results. Either they cause losses in capacity or increase production load. Almgren (2000, pp. 4587-4584) categorizes the disturbances by results or source. The result can be a loss in quantity or in quality. The source is also divided into two and can be either externally or internally generated. Bellgran and Säften (2010, p. 246) have instead divided the disturbances by the affect into capacity, quality or cost. The most typical examples of each title are given in the table 2.2. Almgren (2000, p. 4577) and Fjällström et al. (2009, pp. 179-180) add organization structure, general process problems and problems in product concept to the table.

Table 2.2. *Main disturbance groups and examples (Bellgran & Säfsten 2010, p. 246).*

Capacity	**Quality**	**Cost**
Machines/Equipment	Status of the incoming material	Extra personnel
Material supply	Operator and technician competence	Temporary solutions
Personnel	Product and equipment performance	Extra control and inspections
General processes	Product concept	Organization structure

Almgren's (2000, p. 4587) study reveals that the main sources of production problems during ramp-ups are losses in quality, reduced manufacturing speed, weak operator performance and material shortages. In his earlier study (Almgren 1999) he highlights three major factors that are incoming material, operator competence and product design. Especially the unfinished product design caused quality problems and extra work.

Supplier quality is often emphasized in literature and it is mentioned as one of the biggest sources for production losses. The suppliers should deliver right status material, in right quality at the right time, so the requirements are extensive. Almgren (2000) noticed that especially the delivery at the right time is often the problem. Other matter is that the problems concerning the material status are normally results of the late engineering changes. The suppliers failed to update their tools and production methods after the issued changes. Ramp-up is a demanding process for the entire network. It is important to ensure that every supplier and network member can handle the needs not only according to the planned schedules but also even during the changing situations. (Bramley et al. 2005.pp. 260-262)

Long lasting tests and testing equipment can also cause delays. New products require extensive quality assurance before approvals. Sometimes even every product needs to be tested. This can be major bottleneck for volume increase if there are problems with testing equipment or parameters. The testing can also mean manual procedures. Almgren offers an example concerning a temporary late inspection team at the end of a production line. This team reviewed the items and upgraded the semi-finished products with modified or missing parts. (Almgren 1999.)

2.1.8 Control and measurements

There are various opinions in the literature concerning the ramp-up performance indicators. Winkler et al. (2007, p. 104) advise to classify the most important ramp-up targets as general project goals into three groups: effectiveness, deadline and efficiency goals. The examples are mentioned below.

Table 2.3. *Possible project goals for the ramp-up (Winkler et al. 2007, p. 104).*

Effectiveness (Result)	
	Resource development for higher productivity
	Following the planned targets in production quality and quantity
	Improving the quality to the required level
Efficiency (Minimum input)	
	The costs of the project and the implemented system are kept moderate
Deadline (Time)	
	Deviations from the timetable are avoided, the deadline is not exceeded

Almgren (2000, pp. 4582-4586) presents three other useful indicators for evaluating the final performance. The last final performance is divided into three.

Table 2.4. *Other ramp-up performance indicators (Winkler et al. 2007, p. 104).*

Throughput time		
	Project duration from pilot production to hand out	
Final efficiency		
	Realized man-hour costs compared to the calculated standard cost	
Final performance		
	Quantity performance	
		Amount of production compared to the plan
	Product conformance	
		Number of faults per produced unit
	Product quality	
		Products without defects/total production

Raising the production efficiency by using disturbance elimination and problem solving can be regarded as one of the top goals during a production ramp-up. Therefore there is a need for more detailed indicators to develop the processes by analyzing the deviations in the collected measurements and figures. Monitoring can also help the development efforts. The success of the made process changes can be evaluated with comparing the new measurements with the older results.

One set of measures to monitor a ramp-up project is presented by Terwiesch et al. (2001). The indicators include yield, rework, testing hours, process failures, tact time and downtime. Yield or first pass yield is a production indicator where the production without rework is compared to the parts that entered the process.

Terwiesch and Bohn state that yield used with production rate is the most important ramp-up indicator. This information contains the improved results of the relevant elements including continuous learning. It is possible that the yield newer reaches the economic breakeven point or it is so low that there is not enough time to pay back the initial investments in tools and design. During the ramp-up a tradeoff between production rate and yield improvement has to be made. Slower speed gives people more time to learn and adjust the process. (Terwiesch & Bohn 2001.)

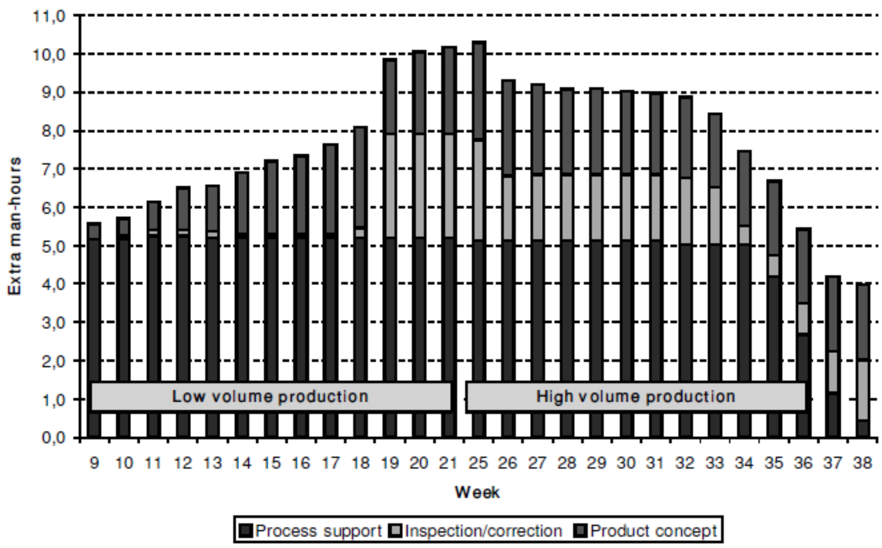

Figure 2.3. *The ramp up costs on a weekly basis (Almgren 2000, p. 4586).*

Ramp-up costs are discussed more in Almgren’s later study. It was presented earlier how disturbances are either quantity or quality related. Both of these cause deviations and therefore extra costs. When these realized expenditures are compared to the calculated standard cost, the overruns during a ramp-up can be regarded as ramp-up costs. The extra costs are directly related to quality and capacity losses and therefore it is a good indicator to reflect the development of the processes and the maturity of the production system. Almgren (2000, pp. 4582-4586.)

2.2 Global production networks

During the 19th century corporations have learned to do business in different cultures and to manage factories in other societies. The new global challenge of this century is to manage the grown network of factories in a way that brings bigger profits with the help of international synergies. The literature offers the principles but many issues remain unsolved. The network cannot be designed just based on a financial foundation. Every location requires a certain amount of locality. Therefore the biggest challenge is to find the balance between adaptation and global efficiency.

Large international organizations have typically been called as multinational corporations or MNCs. They have a strong centralized management and a network of factories and subsidiaries around the world. They might have common products and develop the activities mutually by using the best practice procedures in the network.

The requirements of the global competition are demanding. The companies should concurrently achieve lower costs, higher quality, faster product introduction, more flexibility and shorter delivery time. To attain these targets there are alternatives to organize and control the enterprise. It is not possible to choose a structure that is better than the rest. A solution can be more suitable for one industry than for the others.

2.2.1 Network management and control

Faulkner (2006, p. 665) suggests using the term multinational corporation as an umbrella to gather the different organizational structures. The alternatives are portrayed in the image 2.9. The simplest and most typical method to start the internationalization is to begin as an international exporter. A good example of this alternative is a company having only one factory and with no alternative products or variants for the export markets.

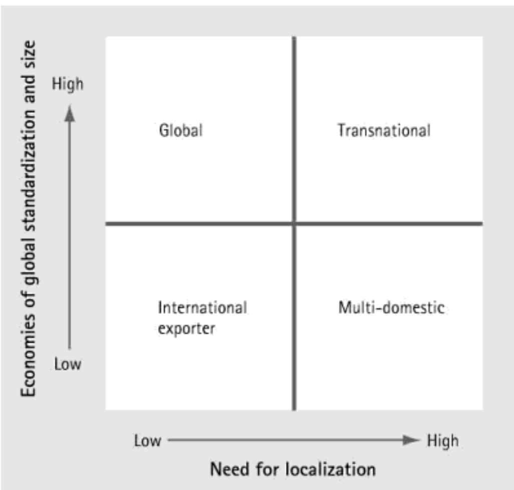

Image 2.9. *Corporate structure matrix (Faulkner 2006, p. 665).*

The global structure represents organizations that push for global efficiency such as manufacturers of consumer products. They offer the same products worldwide and use only minor adaptation no matter where they operate. Decision making and knowledge development are strongly centralized. The subsidiaries are strongly controlled and managed as supply chains that produce and sell the products. The benefits of scale are a major driver to choose this solution. (Tiainen 2008, pp. 18-20.)

The multinational structure can be described as extremely responsive. The alternative focuses on local adaptability in products and processes and lacks therefore some of the benefits of scale. (Tiainen 2008, pp. 18-20.) Ghislanzon et al. (2008) describe a similar subgroup and calls it multilocal solution. It means corporations that have a strong domestic character such as telecommunication operators and food producers. They adapt their operations and offering for the local needs with only moderate network control.

The last and the newest structure is the transnational solution that tries to overcome the weaknesses of the other solutions by joining local responsiveness and the benefits of scale. A transnational enterprise is managed as an integrated network and the target is not the success of individual sites but of the entire network. Decision making and management activities vary according to the subsidiary's strategic role in the network. Subsidiaries are managed rather as partners than slaves. The structure requires learning from others and global transfer of innovations. The key point is to focus on the management of flows. The flows can signify for example components, products, people and funds. (Faulkner 2006, pp. 665-670.)

Table 2.5. *Alternative methods to control subsidiaries (Ghislanzon et al. 2008).*

Cross-unit	Description	Sample mechanism
Centralized structure	Central decision making and execution	• Central unit or function sets policies, makes the decicions, and executes them
Centralized decisions, local execution	Decisions and policies defined centrally but executed locally (ie. within country organisations)	• Specialized management roles (eg. procurement and key-account managers) • Common improvement process (eg. lean)
Aligned execution	Decision making primarly in local country organisations Some centrally driven coordination for alignment and optimization	• Best practice sharing • Formal network of functional leaders • Rotation of people • Common reporting formats
Decentralized	Decisions and execution fully local	• Strong country general manager

It can be difficult to point out a company's location in the image 2.9. Even the processes and products can be controlled differently. Therefore there can be a need for other similar but more detailed frameworks to describe the network control more specific. Ghislanzon, et al. (2008) offer a solution in the table 2.5. The matrix describes four different methods to control the network and subsidiaries.

2.2.2 Plant roles and global supply chain

Plants normally have different location specific advantages and reasons for existence. The main ones are the proximity to a market, the availability of labor and the proximity to suppliers. The proximity to market can be regarded as the most important while the others have much less relevance. (Vereecke 2009.)

Table 2.6. *Different site roles based on the dimensions (Ferdows* 2009).

		Low Cost Inputs	**Technological Resources**	**Market Proximity**
Competence and extent of activities	**High**	Source	Lead	Contributor
	Low	Off-Shore	Outpost	Server

To benefit from the location advantages the most, factories possess different roles in the networks. The Ferdows' (2009) framework defines the role based on two dimensions. The first is the reason to establish the site and the second is its technical competence. The competence means capability to take responsibility for the product or process design or design changes. The framework is presented above.

- An *offshore* factory benefits from the low cost inputs and produces rather simple products. Little technical and managerial expertise is involved.
- A *source* factory is as the earlier offshore site but produces parts requiring more specialization and expertise. It also has the most developed processes.
- A *server* supplies for some local or regional market and has expertise to make small adaptation for the products.
- A *contributor* serves regional markets, develops products for this area, supplies knowledge for the entire network and searches for suppliers.
- An *outpost* site is located in some technology center and is responsible for gathering information. It often has some other additional role.
- A *lead* factory has the highest level of expertise and develops processes and products for the network. It possesses strong techological capabilities.

Global management typically means centralized decisions and policies to control the activities in the network. Literature describes the responsibility to control the supply chain activities as one part of a site's autonomy. Global coordination might bring not only efficiency but also tradeoffs. Good examples of the typically centralized decisions are forecasting, scheduling and inventory. Sourcing is another aspect. Entirely independent sites can simply choose their own local suppliers and are also allowed to develop the relationships without control. The other extreme is that the global sourcing function offers the alternatives and makes the procurements. (Meijboom and Vos 1997, pp. 164-167.)

Vereecke's framework offers another viewpoint. It categorizes the sites by the flows of information and innovation. The role does not depend on luck. Instead the path to become an advanced network player requires a clear and explicit strategic commitment to increase the factory status. It is necessary to have at least one network player in the grid due to the need for making the innovations somewhere. Veerecke gives two methods to transfer the knowledge and innovations. The formal information can flow with documents but the informal knowledge transfers when the employees visit the other sites and chat with each other. (Vereecke 2009.)

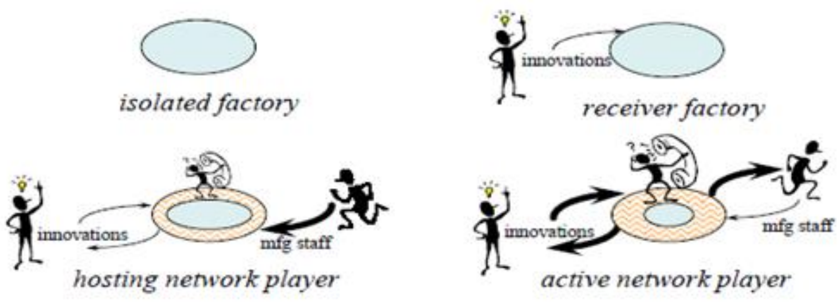

Image 2.10. *Different network roles (Vereecke 2009, p. 24).*

Isolated and receiver factories do not have much cooperation with the other members. They can also be described as the flexible part of the network as they are relatively easy to establish and close down in search for new advantages. The hosting and active players signify more developed roles. (Vereecke 2009.)

- *An Isolated factory* is an independent site that does not exchange innovations or information with others. The factories are typically young and regional.
- *A Receiver factory* receives innovations and technology from the lead site and centers of excellence. It often has a low level of managerial expertise.
- *A Hosting network* player communicates regularly with the other network members. It develops and receives innovations and typically hosts visitors from the network and offers training and development of solutions.
- An A*ctive network player* innovates and communicates as a hosting player but also pays attention to learning from others inside and outside the network. The employees not only host visitors but are also active in visiting other sites.

Table 2.7. *Strategies for global operations (Daschenko 2006, p. 12).*

Global Integration of Production Activities	High	Geocentric global manufacturing	Hybrid manufacturing strategies
	Low	Ethnocentric international manufacturing	Polycentric multinational manufacturing
		Low	High
		Local adaptation of production activities	

Another framework for international manufacturing is presented in the table 2.7. Daschenko's model is very similar to the Faulkner's (2006) one presented in the image 2.9 but is more manufacturing oriented. The extreme strategic choices are geocentric global manufacturing strategy and polycentric multinational manufacturing strategy. (Daschenko 2006, p. 12.)

- Ethnocentric strategy is the same as an international exporter. There is no need for integration or adaptation as there is just one factory.
- Geocentric global strategy is typically used when manufacturing processes are very capital intensive and there is a need for high utilization rates to be cost efficient. The production is done in large sites with specialized machines.
- Polycentric strategy means decentralized manufacturing with reconfigurable machines for local markets. This local strategy is the choice if customization, flexibility or regional products with smaller volumes are needed.
- Hybrid strategy is an integrated solution that can mean regional assembly with the help of benefits of scale. The parts and tasks that benefit the most of efficiency are outsourced or centralized. The final assembly can be decentralized to serve regional areas to offer flexibility and customized products. Transferable small satellite assembly factories can be a solution if extreme flexibility is needed.

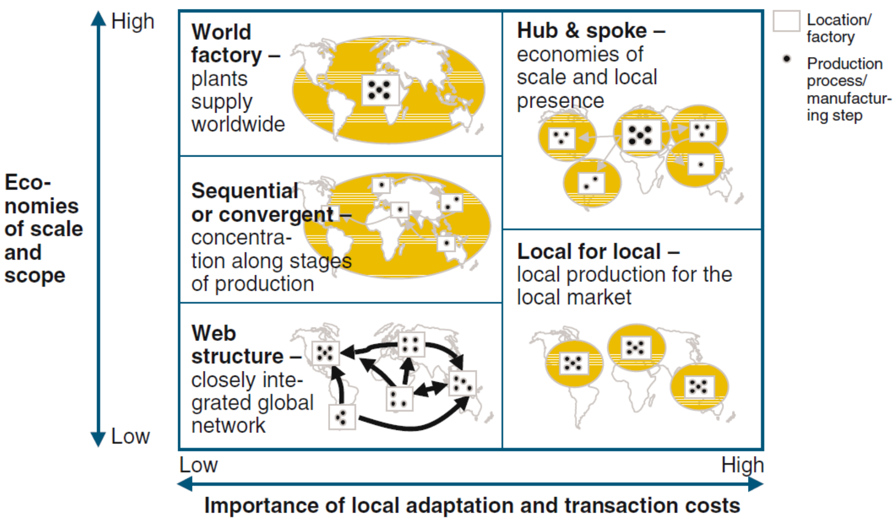

Image 2.11. *The alternative network structures (Abele et al. 2008, p. 164).*

Abele et al. (2008, pp. 164-167) present similar ideas in the image 2.11 as the earlier frameworks but describe the roles more detailed from the network's point of view. The spots mean different processes or production steps and the arrows signify material flows. The left bottom corner is different from the earlier models. The sequential or convergent structure means that the phases are centralized in locations offering the best advantages. The network with web structure allocates production across the network to optimize the costs.

2.2.3 Standardization or adaptation

The value of standardized offering and operations depends on whether people or companies are served. The importance of local tastes and services increase when an individual is concerned whereas globally standardized processes and products offer major benefits for the business customers.

Both alternatives have benefits for the network as well. The local adaptation makes it possible to exploit local advantages such as cheap labor. It can also be a source of entrepreneurship as the employees can have an influence over their own work. Ghislanzon et al. (2008) advice managers to evaluate each process and to determine whether they create more value when standardized or localized. The critical ones from the network's point of view should be standardized to simplify cooperation and the flow of information inside the company. The rest are more valuable when adapted. The benefits of both aspects are described in the table 2.8.

Table 2.8. *The benefits of standardization and adaptation (Tiainen 2008, p. 26).*

Standardization	Adaptation
Shared image and process understanding	Better utilization of innovations
More efficiency and less global variation	Understanding of local needs
Worldwide cooperation lowers the costs	Utilization of local advantages

Global product transfers practically mean transfer of processes, information and knowledge. Despite of the benefits of standardization some adaptation is always required. Table 2.9 presents three stages of adaption of manufacturing processes. The lowest level means that there is no need to redesign the product as only the processes and tools not affecting the product design are adapted. The other two stages of adaptation affect the production system so that the product design needs to be modified. The difference between these two is that the comprehensive level results into radical design changes affecting the customer value. (Abele et al. 2008, p. 204.)

Table 2.9. *Levels of adaptation (Abele et al. 2008, p. 204).*

Level of adaptation	Adaptation of production technology	Adaptation of product design
Low	• Material flow • Quality control	• Auxiliary parts
Moderate	• Workpiece handling • Jigs and tools • Monitoring and parameters	• Product design • Core components
Comprehensive	• Production technology • Process chain	• Product functionality • Value to the customer

Copying matured processes radically decreases the need for testing and process engineering. This reduces development costs and enables faster implementation. Standardization also secures the compatibility throughout the organization and network. The challenge is that the process needs to be suitable for the receiver environment as well. Other issue to consider is whether it is even possible because of the different cultures and environments. (Grant & Gregory 1997.) The transfer of the process frame with the main ideas using local execution can often be more beneficial.

Grouping the sites by size or region is one solution if the global standardization is not realistic. It enables to standardize processes for certain regions if some of them benefit from the adaptation more than others. (Ghislanzon et al. 2008.) Abele et al. suggest considering to develop two sets of manufacturing technologies. The first with more automation would be used in the developed countries while the simpler set would take advantage of the lower costs. (Abele et al. 2008, p. 193.)

Ghislanzon et al. list three barriers for the transfer and adaptation of processes. The managers are typically not aware of the benefits and possibilities of the cooperation. Yet they should evaluate the processes and choose the ones to standardize. They might also have insufficient personal tools such as poor language skills or awareness of different cultures. This could lead into poor communication and unwillingness to cooperate. Low motivation can also arise from worries of loosing autonomy or control of the site. Standardization can also bring fear of stronger managerial pressure. To avoid these barriers the standardization process should include training and task rotation. (Ghislanzon et al. 2008.)

2.2.4 The needs for transferability and the definers for adaptability

The benefits and barriers concerning the transfer of both standardized and adapted processes were discussed above. Yet the requirements to transfer a cloned process need to be defined more detailed. Before anything should be copied or transferred it is necessary to consider the solution’s appropriateness for the new locations. There can be obstacles such as lack of managerial skills, poor infrastructure, poor suppliers, regulations and different environmental conditions. (Grant & Gregory 1997.)

A robust process signifies appropriateness for the different environments and can be transferred without adaptation. Transferability on the other hand signifies capability to transfer the process and the information involved. These issues should be assured before implementation and preferably as early as possible. This requires process understanding and knowledge of the other environments. If these considerations are neglected the inappropriateness can emerge later during the implementation. A systematic transfer model, checklists or an index to measure the tolerance to variable conditions can be useful to assure a sufficient evaluation. (Grant & Gregory 1997.)

The different levels of manufacturing process adaption were described earlier. The level can be low, moderate and comprehensive depending on the modification's effect on the product design. Abele et al. have put together the most important definers for adaptation when establishing a new factory. The items are listed under five titles. The most significant reasons are costs of labor and capital, production volumes, skills and product specifications. (Abele et al. 2008, pp. 194-200.)

Table 2.10. *The factors defining the level of adaptation (Abele et al. 2008, p. 194).*

Skills/qualifications	
The level of education and general experience of employees • Skills are the key issue when production automation and complexity are considered. • Training can be problematic if the employees change frequently. • Low skill level motivates to divide work into smaller and more controllable phases. • Requirements should match with the skill level achievable in 1-2 yars.	
Factor costs	**Unit volume and flexibility**
The total costs of the process or work phase • Typical costs are salaries, machine maintenance, cost of capital and costs of more accurate tolerances. • The costs of each alternative should be calculated to achieve a complete evaluation.	The choice should be made by summing up the needs in flexibility, volume and costs • Consider the expected volume. • What happens if demand decreases? • What if demand increases radically? Automation, more people or new line? • Prefer manual work if demand deviates.
Customers and local suppliers	**External conditions and risks**
The environment can force the company to adapt the product and the processes • The market requirements for variants • The market can demand cheaper prices and adaption of product quality. • Similar parts and materials might not be available in different locations. • The processes need more robustness.	Problems caused by the geographic location • Specific customs duty rates that make global sourcing difficult • They force the companies to have wider extent of production activities at site • Piracy and competitors know-how thefts are the most typical factors motivating to consider decentralized production.

Colotla et al. presented an example of what happens if the need for adaptation is ignored. A Danish company established two new factories in low cost countries and transferred the old production lines of a matured product with using only minor process and supplier adaptation. Many problems occurred. The raw materials traveled weeks and waited in inventories. The spare parts inventory of the customized automation systems was located in Denmark. This caused long delivery times because of the transport and customs. This had a strong impact on performance and WIP inventory levels. The machines were designed for short-term flexibility but were incapable of changing longer term volume or mix demanded by the new markets. Finally, as the processes and practices were mostly cloned, the locals did not know how to develop them after the transfer. (Colotla et al. 2003.)

2.3 Managing the global ramp-up

Decentralized production responsibility means more ramp-ups. Although the first is the most complex due to the engineering changes the following ones remain challenging as well. Despite of the time pressure, the workers need to be trained and the processes have to be adapted to suit the other location. Finally everything should be verified to assure high quality. Abele et al. (2008) offer three alternative strategies to conduct these product transfers.

- Model factory – The use of standardized layout, equipment and processes
- Minor changes are allowed if they do not affect the output
- Radical changes to exploit local advantages

There are two extreme alternatives to carry out a global ramp-up in a multisite manufacturing network. The first is to use a group of separate local transfer projects. It requires less central management but misses the benefits of information and knowledge exchange. The more complicated solution is to establish a larger integrated project with more coordination and collaboration between the separate projects. The case company of this thesis has adapted aspects of both alternatives and the current solution is somewhere in the middle of these two methods.

This chapter illustrates first the needs and possibilities in sourcing and knowledge transfer. Next the idea to consider the global ramp-up as a project and program is described and the benefits of the improved integration are explained. Finally two examples from the literary on how to tackle some of the problems are presented.

2.3.1 Global or local sourcing

A typical opinion is that the tradeoff in global and local sourcing is made between time and price. Local suppliers should mean flexibility and less inventory while global purchasing offers lower prices with the help of larger batches and better contracts. The researchers suggest a contrary solution. It is advised that the choice should be made between time and quality because local suppliers often mean worse quality which requires higher inventories. The parts with risks should be recognized beforehand. A typical method is to categorized the items into critical and non-critical ones. It is important especially if both global and local sources are used. (Meijboom & Vos 1997.)

Abele et al. stress considering that the realistic price might require adding extra costs to the price because of the work caused by the evaluation process. In addition the local suppliers need training and help to achieve the requirements. Therefore the process of sourcing and evaluations in low cost countries can take twice as long compared to the time in developed countries. (Abele et al. 2008.)

Local suppliers offer the biggest benefits if there is a need for low volume parts or there are difficulties with the transport. Lack of local engineering skills at site however can be a major problem because the feedback loop between the local suppliers and the lead factory might take too long. The multinationals should first gather experiences and improve relationships with the locals. Later on it is possible to source more complex parts from the selected companies. The organization should have close cooperation with the best suppliers and solve the issues that hold off the local partners' further competence development. To be successful in this, a competitive local sourcing function is required. (Abele et al. 2008.)

Table 2.11. *Strategies to manage parts and suppliers (Abele et al. 2008, p. 324).*

Strategic partnerships	**Global sourcing**
• Technically complex parts • Risks in quality or loss of know-how • Company's intellectual property • Use trusted partner suppliers only • Cooperation with central purchasers • Possibilities for insourcing	• High volume standard components • Low logistic costs • Various possible suppliers • Find the cheapest global supplier • Use current suppliers • Cooperation with central purchasers
Local supplier development	**Local quick wins**
• A bit more complex parts • Currently no local skills available • Develop selected local suppliers or ask current suppliers to follow	• Simple parts, easy production • Relatively expensive to transport • Possible to source with short notice • Objective to eliminate logistic costs

Segmentation of the sourced parts can be useful if the source needs to be determined. Table 2.11 presents four alternative categories for this. The parts segmented as local quick wins signify parts that offer easy costs savings when sourced locally. Items in the group of local supplier development mean parts with a bit more complexity. These parts should be sourced from local suppliers who have increased and proved their competence. It is practical to define a specific sourcing strategy for each group. (Abele et al. 2008, pp. 325-340.)

The cooperation with the local suppliers in low cost countries should begin with the simpler parts. The responsibility of the more complex ones can be transferred later on if the local suppliers are able to prove to be capable of supplying them. Abele et al. give two suggestions to avoid major supplier related quality problems. New parts from local suppliers should be introduced sequentially to avoid simultaneous disturbances and quality issues. Other suggestion is to keep on sourcing from the earlier global suppliers concurrently with the new local ones. The local share can be increased as the shipments achieve the targets and the quality can be assured. (Abele et al. 2008, p. 324.)

2.3.2 Training and knowledge transfer

To transfer any process, practice or piece of information to another location, there is a need for training and discussions for which there are various alternatives. The transfer can consist of virtual or real interaction depending on the needs and resources. Training can also mean a mix of the different methods described below. (Grant & Gregory 1997, p. 1001.)

- Documents
- Face-to-face training
- On-the-job training
- Videos
- Visits

Another flow to consider is the knowledge transferred upwards or horizontally from a local site. The tacit knowledge created at the local sites is described as the most valuable asset of the company (Andersson & Lagerström 2003). This know-how should be shared across the organization. A typical method to conduct the transfer is to send a manager for a visit to draw up a written description. Naturally this does not bring much success. It only enables to transfer explicit information although the tacit knowledge is the more important source of success. (Greyson & O'Dell 1998.)

The most effective method to transfer tacit knowledge is to enable the visits of the right people to regional sites. This knowledge can only be transferred with the help of real contacts and conversations in a supportive atmosphere. The technology can support this by offering contact databases that help finding the right people and the most suitable solutions. The responsibility to maintain the contact information should be centralized to a one person per site. (Greyson & O'Dell 1998.)

Terwiesch et al. present an example of a heavy training made by a global hard disc drive company. It transferred the production of a new product and aimed at starting high rate production as fast as possible. The R&D organization and the pilot line were located in the USA while the production facility was located in Singapore. The Asian factory was equipped similarly as the pilot factory and the processes developed in the USA were copied there. (Terwiesch et al. 2001.)

Ramp-up teams existed both in the pilot line and in Asia. The Asian team manager arrived in the USA 6 months before the transfer to coordinate the project. The rest of the team came 50 days before the transfer while the operators had an assembly training of one month. The staff returned shortly before the transition. Similarly engineers such as failure analysts, tooling and information specialists from the USA were moved to Asia to assist there. The transfer of people improved communication and was very helpful because of the time difference. (Terwiesch et al. 2001.)

To improve the flow of knowledge and to create new tacit knowledge Andersson and Lagerström suggest forming cross-border transnational teams that exploit both social interaction and information technology. These teams can be very useful if there is a need for a single global solution. The teams also make it possible to create solutions that can be easily implemented and adopted to different cultures and units. The members from different locations with various backgrounds are responsible for sharing the created knowledge at their own units. (Andersson & Lagerström 2003.)

Andersson and Lagerström present a study how a transnational team was gathered and used to specify the general needs for a global IT-project. The team was temporary but full-time. The staff was located at their own local sites after the kick-off. The biggest negative issue according to the team members was the lack of real interaction or in other words lack of live meetings with other team members. (Andersson & Lagerström 2003.)

The transfer of the best practices has long been a common area of research and consulting. There lays a huge potential of savings but multiple obstacles need to be overcome. The success does not come without efforts as the practices do not simply transfer from point to point. First the practice is recognized, then learned and finally transferred. The entire process can take surprisingly long. (Greyson & O'Dell 1998.)

Although the use of tools to transfer the practices might be helpful they do not change the need for cultural change and management’s strong support. The crucial point when finding the best practices is the concentration on breakthroughs instead of arguing what the best solution might be. (Greyson & O'Dell 1998.)

2.3.3 Global project, program and portfolio management

The ramp-up management is typically very project oriented. Although the situations are different, all projects can typically be grouped under five titles. The general alternatives are traditional, distributed, international and virtual. A global project is a combination of international and virtual types and has team members representing various organizations in different countries. (Binder 2007.)

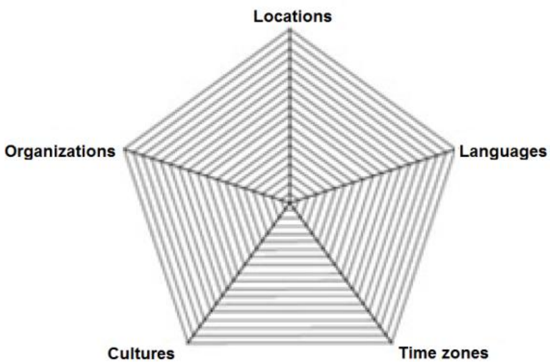

Image 2.12. *Defining the complexity of a global project (Binder 2007, p. 3).*

Binder (2007, p. 3) suggests evaluating the complexity of a global project with 5 dimensions presented in the image 2.12. The project's degree of difficulty depends on these aspects that consider the challenges in communication, cultures and different objectives. The evaluation can be made both for the team and stakeholders.

The idea of global project management presents well the earlier transfer projects made by the case company. However, the changed situation and the more global aspect require a new approach. Furthermore, projects have only one project manager and a single defined project team while global ramp-ups in the case context consist of multiple projects executed by various teams and managers.

Andersen presents an alternative to divide large projects into subprojects. This is one alternative to conduct the ramp-up but the method does not offer any solutions to improve the overall cooperation and communication between the stakeholders. (Andersen 2008 p. 282.) To cope with the integration challenges, the literature offers program and portfolio management. The contents of these two are often mixed so a detailed specification of both is given according to Dwyer et al. (2009, p. 4).

- **Program** "A structured process of managing multiple on-going projects within an organization. The focus of program management is the alignment of on-going projects with the goals of the organization; thus the aim of a program is to group related projects that warrant optimum coordination of resources at the most beneficial allocation for the organization."

- **Portfolio** "Simply a collection of programs. Portfolio management is about selecting a combination of programs that will give the organization the most optimized profits at the lowest risk." The projects and programs in the portfolio do not necessarily need to have and share anything in common.

Program management can be said to be more suitable in the context of this thesis. Particularly interesting is the fact that project management can be seen as tactical while program and portfolio management are more strategic. A program manager should focus not only on the coordination of single projects but also on the benefits of the entire program and manage the big picture instead of controlling the project specific details. The manager should improve the integration between the projects, improve the use of resources and ease the required multiple project management procedures. Above all the manager should focus on the themes listed below. (Sanghera 2008, p. 35.)

- Benefits management: Develop activities to maximize benefits.
- Program governance: Monitor and manage the program and integration.
- Stakeholder management: Manage the external influences and expectations.

2.3.4 The global ramp-up as an integrated program

The image 2.13 represents a matrix of alternatives to define the global program more specifically. The available solutions differ in the number of locations of stakeholders and project members.

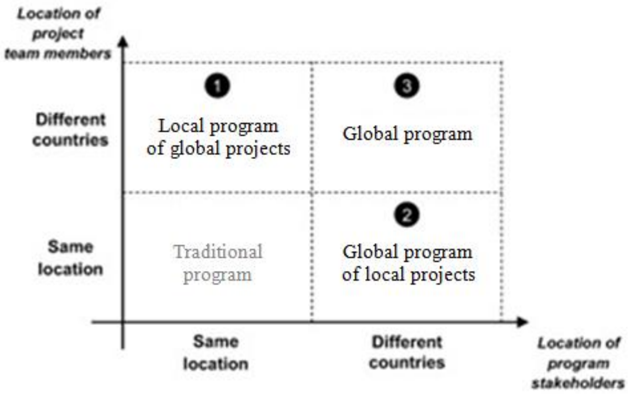

Image 2.13. *The alternatives to execute a global program (Binder 2007, p. 4).*

Alternative two fits perfectly within the needs of this thesis. A global program with local projects means multiple projects located in various countries. The aim of the local projects is for example to implement a similar solution such as an IT-system for each site. The solution is visually presented in the image 2.14. The other two alternatives are relatively different. They signify either managing all of the international projects from the same location or conducting various global projects in different countries.

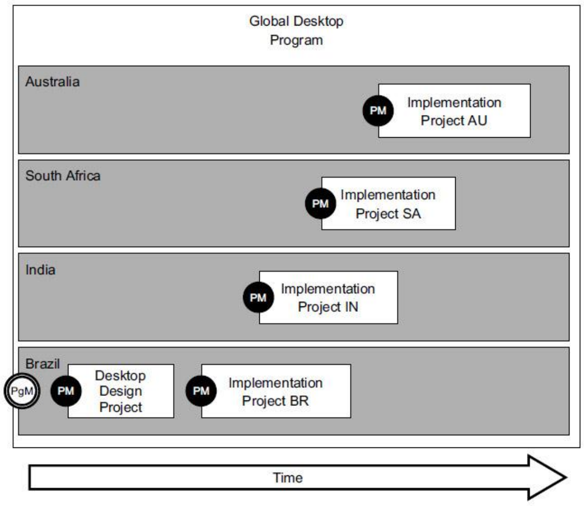

Image 2.14. *An example of a global program of local projects (Binder 2007, p. 7).*

Barkley and Wagner (2009, p. 306) add a detail that western programs are often managed according to loose-tight strategy. This means maximizing local decision making while tightly controlling the critical and shared processes and issues. This method describes very well the management style emphasized in the case company.

2.3.5 Key tools to manage the program

A program should be considered as a strategic approach, while single projects should be managed to achieve a set of integrated business goals of a program. In a global ramp-up this could mean the creation of an integrated global manufacturing system in a time to market as short as possible. The program should have own strategy and the objectives should be aligned with the company level business or manufacturing strategies. The main target of the projects is to follow the plan. This is why the project and program management are different in nature. (Milosevic et al. 2007.)

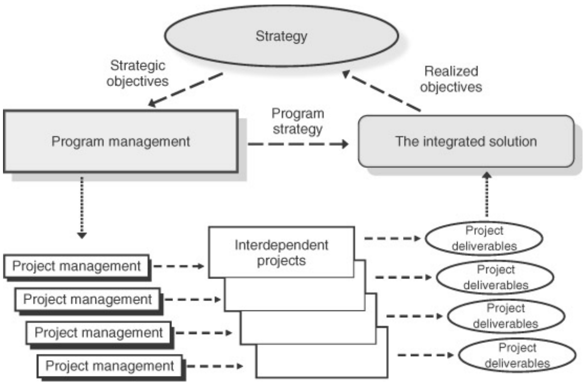

Image 2.15. *Program strategy (Milosevic et al. 2007).*

The program life cycle should be divided into phases and gates to improve the management. It should begin with planning and end with a proper review. The management should consist of five types of activities: initiation, planning, executing, monitoring and controlling and finally closing. Monitoring and controlling should happen throughout the program but the rest are more related to the current phase in the gate model. (Barkley and Wagner 2009, p. 62; Sanghera 2008.) Andersen (2008, p. 285) has a different opinion and states that programs are different in nature so no heavy structure is necessarily required.

Image 2.16. *Different program stages (Barkley and Wagner 2009, p. 62).*

An alternative method to consider the planning and execution from a new perspective is to create a program work breakdown structure (PWBS) (Sanghera 2008, p 166). This means dividing all the work in a program into projects and work packages as presented in the image 2.17. Although the hierarchical tree is only part of the PWBS process it is the most visual output. The division into work packages helps understanding the similarities between the projects which gives a better understanding for the possibilities to share solutions and to coordinate resources. To avoid excess complexity the number of levels should not exceed five.

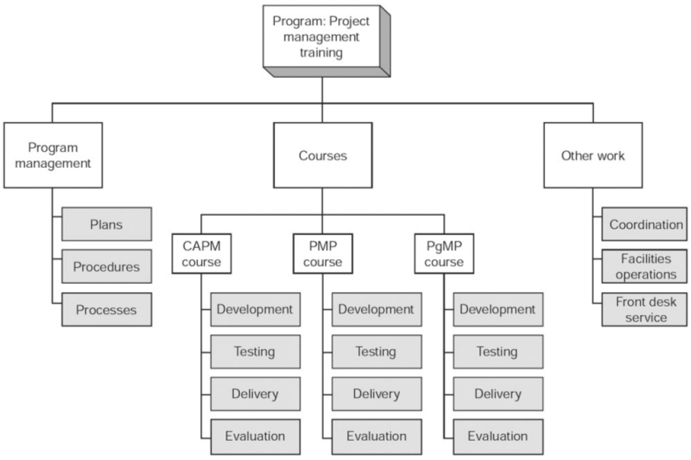

Image 2.17. *Building the work breakdown structure (Sanghera 2008, p. 166).*

Program support office (PSO) in the image 2.18 means a team of people from various functions. The office is supporting the program and helping members to use and implement the project tools, procedures and processes. (Binder 2007, p. 165.)

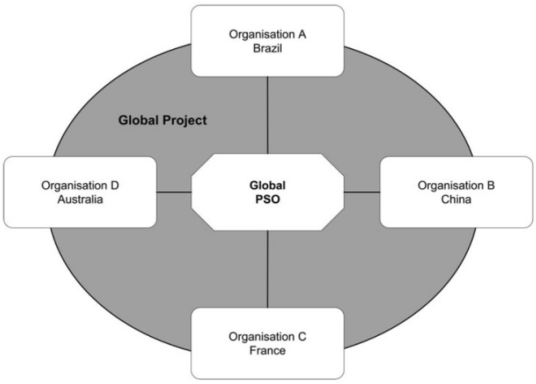

Image 2.18. *Program support office (Binder 2007, p.165).*

The idea of a program core team is presented by Milosevic et al.. It should include the most relevant program staff responsible for the program success such as project managers and the members of the PSO. The program manager is the head of this group and responsible for facilitating the communication and collaboration in the team. The members should integrate their projects into the program plan, support on problem solving and participate in program level decisions. (Milosevic et al. 2007.)

It is typical to define a plan on how the areas of communication and collaboration are managed. The target is to assure that the program members are kept up-to-date concerning the program information and related issues. The main requirements for the communications plan are listed below. (Sanghera 2008.)

- What are the communication and information needs of each stakeholder?
- 4 x W: What is needed and When, Who needs it, and Who will deliver it?
- How the information is being delivered (email, phone call, presentation)?

2.3.6 The alignment of the local projects

Another issue to consider is the schedule of the projects inside the program. The first decision is whether the ramp-ups should happen concurrently or sequentially. The next question is if the processes and the transferred practices should be developed after every ramp-up. No unambiguous researched answer could be found for this.

One alternative is to use the ideas of the multi-project strategy framework presented by Cusumano and Nobeoka. Their model concentrates on the problem of design transfer between R&D projects. The researchers point out that the rapid design transfer is the most efficient method to reduce engineering hours when technology is transferred between projects. This is because it enables task sharing, information exchange and mutual adjustments. In addition the members involved in the earlier project are still available for discussions about their experiences. Later on they might work with other projects in new locations. The similar alternatives 3 and 4 in the image 2.19 use radical technology evolution while the rapid design transfer means incremental development. (Nobeoka & Cusumano 1995.)

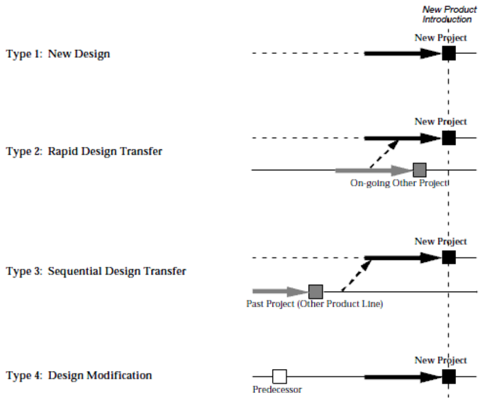

Image 2.19. *Alternative methods for design transfer (Nobeoka & Cusumano 1995).*

Other challenges affecting the scheduling decisions are the risks and the availability of resources. Modern project management uses business process simulation to manage these factors. Although a project is not a typical business process, the simulation can be very beneficial in finding possible risks and assuring the availability of resources. Before a simulation the processes and project steps need to be visually modeled. This can be made with a gantt chart. (Dickstein & Flast 2009.)

The simulation does not necessarily require any computers although they might offer answers for more complex questions with proper probabilities. Using a pen and paper in following the project description or the model is often enough. It helps defining the required inputs and outputs on each phase. Simulating the availability of resources and possible risks with scenarios is another benefit. The scenarios could contain possible problems and sudden changes. (Dickstein & Flast 2009.)

2.3.7 Assuring the success in the cross cultural communication

Global program management faces slightly different issues compared to a domestic one. It is much more complex because the risky and uncertain environment contains various societal, cultural and political challenges. These can be managed only if the organization is adequately prepared. (Barkley & Wagner 2009, p. 369.)

The global collaboration should include training, a successful start-up, good relationships and fluent communication. According to Phillips (1992, p. 109) a balanced and successful international team is not about people necessarily liking, but respecting each other.

Starting an international project
The importance of a good start for a long term success is highlighted in various sources. Andersen distinguishes the start and start-up of a project. The difference is that a project is started when the project is established and a manager is appointed. Project start-up signifies a procedure of various activities. (Andersen 2008, p. 127)

- Discussions between the project owner and project manager
- Planning and organizing the project
- Kick-off meeting
- Creating a written plan and description of the project
- Training of the project members

Fisher and Fisher have a similar perspective. A good start-up typically includes a face-to-face meeting where the project plan, strategy and roles are made understandable and the mutual guidelines how to work together are defined. Creating a mutual team contract signed by the team is one possibility to assure the realization of these agreed issues. The most important part however is the formal and informal meeting of team members. This is very beneficial for the future virtual communication. If the project fails or has severe challenges because of poor communication or weak relationships, it is possible to arrange a restart with similar activities to fix the problems. (Fisher & Fisher 2001, pp. 74-76)

The team might define guidelines for the maximum response time in communication. The presented examples were 12 and 24 hours. The response does not need to be the final answer. It could just inform that the message has been received and the problem is waiting to be solved. Another suggestion was to use automatic reply as an e-mail message is opened. This should help avoiding the communication problems caused by vacations and traveling. A third issue is the need to find and agree on methods to avoid unnecessary messages and avoid information overload. In a program environment it might become a major challenge. (Fisher and Fisher 2001, p. 75.)

Building successful communication networks

Berger suggests interviewing the key members before a project begins. This would help the manager to assure the member's level of commitment and enable the team to understand the plans and goals. Other method is to send the people a questionnaire and ask the same questions virtually. An important issue that should be discussed during an interview is the preferred individual specific communication method. Knowing this is a major help for the everyday communication. (Berger 1996.)

The managers should analyze the relationships during the interviews. They should try finding the connections that require reinforcement or have tensions from the past. These weaker links require face-to face meetings both in formal and informal environments to evolve into an adequate level for better cooperation. (Binder 2007.) The image 2.20 presents an example how to map the bonds between the members. The different colors and missing links signify the current status of the relationships.

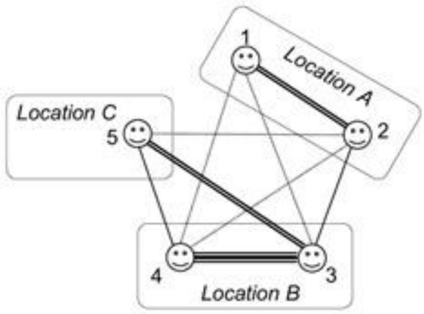

Image 2.20. *Mapping the relationships inside the network (Binder 2007, p. 57).*

A project specific cross cultural training can be major benefit. In stress situations people tend to behave and expect leadership according to their own culture. The managers should recognize this and possibly adapt the managerial activities to offer the required support. The people should not be boxed according to their culture but it is important to understand their behavior in different environments to avoid conflicts. It is stressed that before any training can help understanding other nationalities the participants should first internalize the habits of their culture. (Phillips 1992). The cultural training could handle issues such as:

- How to give feedback
- Understand the implication of the behavior of others
- Information about the customs of other cultures
- How to lead, motivate and reward
- The relationship to time and deadlines (Berger 1996)
- The role of rules, procedures and agreements (Berger 1996)
- The importance of status (Berger 1996)
- Conflict management (Berger 1996)
- Negotiation culture (Barkley & Wagner, 2009)

Maintaining the good relationships

Fisher and Fisher (2001, p. 121) point out the importance of regular face-to-face meetings. Regular could mean such as 4 times during the project, quarterly or when a milestone is reached. The most important is that the team meets after the first visit. Otherwise the lack real interaction might weaken the communication.

Conflicts can be seen as a risk or opportunity. In a conflict two or more stakeholders have a different opinion how to proceed further. International environment with different cultures and misunderstandings increase the amount of these situations. Conflicts can be seen beneficial if they result in an improved solution. Sometimes it is beneficial to motivate the organization to discuss the alternatives. Therefore they should not be simply avoided. However the organization should be prepared for these challenging situations and create a strategy to solve them. There are different methods to manage the faced disagreements. The most appreciated methods to assure the members commitment afterwards are to use problem solving or develop a new solution in collaboration with the members. (Binder 2007.)

One suggestion to consider is the program managers task to give regular feedback for the project managers and members. Fisher and Fisher (2001, p. 69) state that the manager should remember to give feedback instead of advices. One method to maintain and improve relationships according to Barkley and Wagner (2009) is coaching. This means regular discussions about the faced problems and challenges with the project managers and team members. Similar type of activity is mentioned in various sources so it can be seen as a very useful and important method.

Technology

Open knowledge databases can be very beneficial but the challenge is to collect the information. A suggested method to add content is writing and adding all the e-mail responses to a web page. This would mean that no attachment files are used. The messages should contain only links to a certain address that would include the answers and files. These forums or databases should be open for other members involved in the current or future projects. (Fisher & Fisher 2001.)

Barkley and Wagner (2009, p. 306) make an interesting suggestion to make the program management a bit more personal. By this they mean the use of social media such as Facebook to improve the relationships. Another method is to create wiki-based elements to create content. Binder (2007) presents an idea of asynchronous virtual brainstorming. Shared wiki documents could be used in the environment of global programs to foster the information exchange and create innovative solutions despite of the distance and time difference. This would also enable the anonymity in writing and commenting which could enhance the flow of ideas.

2.3.8 Alternative executions to transfer the manufacturing system

The best strategy to make the ramp-up and the transfers successful is to design the product to match the facilities and tools. If there are no existing capabilities they should be prepared before the ramp-up. (Terwiesch et al. 2001.) Therefore a product can be designed optimally for one system only.

The idea of a model factory is to copy the tested and successful proven processes, equipment and layout in order to skip the biggest ramp-up difficulties. The parameters and processes are developed in the lead site so that the quality and production rate targets are achieved quickly and the quality can be assured. The lead site should afterward train the product, production system and processes for other factories. (Terwiesch et al. 2001.) Two strategies inside this category can be recognized. The first avoids changes and is used especially by electronics manufacturers (Terwiesch et al. 2001; McDonald 1998). The other (Kurttila et al. 2010; Rudberg & West 2006; Sonoda 2002) is more orientated for centralized development and is more appropriate for companies with longer life cycle products.

The rest of this chapter presents two different model factory methods to manage the transfers. First the Intel's copy-paste model is presented. The second model describes how to establish identical constantly developing satellite sites and manage the flow of information in the network.

Intel's Copy EXACTLY

Intel's transfer concept is the most developed and researched model currently available. It was developed for microprocessor manufacturing and has returned terrific results. The company struggled with typical ramp-up problems during the late 1980's and it always took too long to achieve the target yields. (Gasser 1998.)

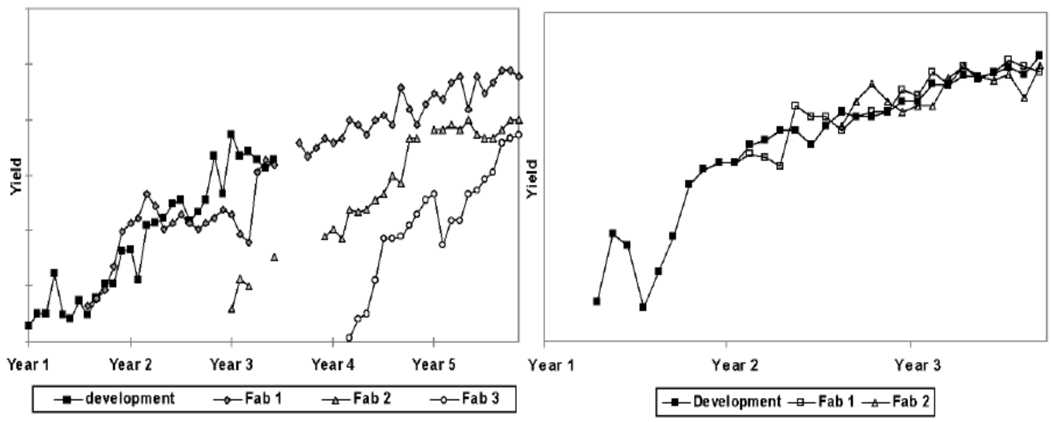

Figure 2.4. *The results of the Intel's old and new method (McDonald 1998).*

The biggest problem was that the following ramp-ups were too slow to achieve similar measures as the first site. The second and third factories received the same factory model but adapted parts of the system using their local knowledge. The seemingly unimportant unverified changes caused disturbances for the entire system. (Gasser 1998.)

The biggest change was to copy the entire optimized system up to the smallest detail. Today every process, tool and input has to be the same. Any change needs to be approved by the development factory to assure the results. After the approval the changes are transferred to other sites so these changes typically have an impact on all of the lines and factories. The factories are always matching but not necessary identical because the new approaches need to be tested before they are spread further. The setting of similar factories helps problem solving as the defects from the model reveal the cause. It not only improves quality and output but also shortens the global ramp-up when the targets are reached faster and easier. (Gasser 1998.)

This concept is very suitable for semiconductors due to the tight tolerance requirements and importance of single process steps. Their manufacturing technology is also expensive to develop. The reasons to adapt are the impossibility to follow the model or the resulting benefits. The reward of avoiding adaptation is that the new lines achieve similar results as the first line immediately. Another important aspect is the ambition to achieve better result than before. (McDonald 1998.)

Companies using the model factories have noticed the good results gained when avoiding changes unless they bring major benefits. The organization should focus on learning and incremental development instead of radical changes which destroy the results of the earlier learning efforts. (Terwiesch et al. 2001.)

Ericsson-Bright light strategy

Ericsson’s model factory concept has been used in the manufacturing of mobile phones and network equipment. The mission was to create a transnational manufacturing solution with the help of researchers. The strategy is described as very generic and can therefore be easily used in other industries as well. Beside of the development advantages the model has received recognition in Ericsson from increasing the efficiency and improving the ramp-ups. (Rudberg & West 2006.)

The model is not just physical with standard equipment and layout. Instead it covers the entire manufacturing system including material supply, information systems (IS), capacity management and quality. It is a clear and standardized model of an ideal plant to produce current products with the given technology. It can be described as a virtual factory that contains specifications and information. The idea is to build all the plants according to the same principles and guidelines. (Rudberg & West 2006.)

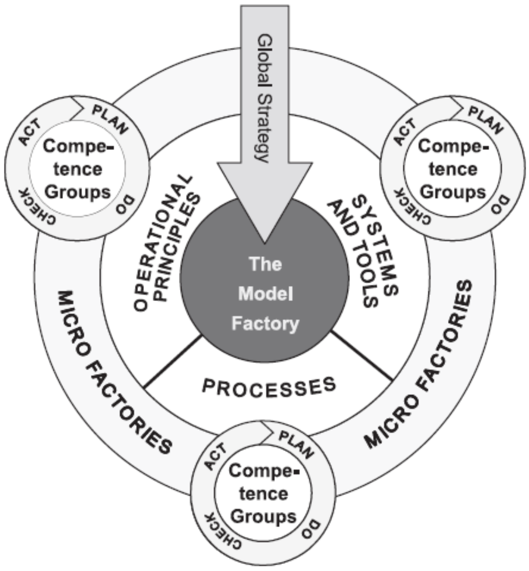

Image 2.21. *The framework of the model factory concept* (Rudberg & West 2006).

The main idea of the model is to describe each value adding activity and process as a micro-factory. Meanwhile, the easiest way to understand a macro-factory is to imagine it as a production line or a small factory of one product family. The micro-factories have either a master or a clone responsibility. The master ones have the expertise and responsibility to coordinate the flow of information and knowledge during the development and product revisions. They carry out new product introductions and develop the required processes. The clone factories need less competence because they are responsible for only using the solutions. (Rudberg & West 2006.)

The competence groups that have a member from every micro-factory meet virtually on a regular basis to share innovation and knowledge. This assures that each location has the latest processes and technology. It helps developing the shared model to be flexible and locally responsive. All development is done according to the Japanese Plan-Do-Check-Act methodology. In the Ericsson's example typically 10 % of the member's work time is spent on the group related tasks. (Rudberg & West 2006.)

The concept is based on an idea of three decision categories. The teams should develop the solutions with the help of these tools and directions. This forces the teams to follow the company's operations strategy. (Rudberg & West 2006.)

- Systems and tools mean a toolbox of equipment, systems and practices.
- The section of processes defines which company level processes need to be utilized and how to use them. Some examples are forecasting and the standardized procedures in the new product introduction projects.
- Operational principles signify policies of management, organization and production.

3 CURRENT STATE IN THE CASE COMPANY

The first part of this chapter presents the case company and the operational environment more detailed. The middle section is dedicated for describing the current state of the local ramp-up process in Helsinki. During the past years the company has made significant efforts to develop these local procedures and it is therefore investigated and described only on a general level. The last third of this chapter is the most significant. It clarifies the level of integration in the global ramp-ups and studies the current processes in more detail.

3.1 The case company presentation

ABB is one of the world's leading companies of power and automation engineering with 116 000 employees and a revenue exceeding 23 billion Euros. Its Finnish subsidiary ABB Oy has approximately 6000 employees and revenue of 2.2 billion euros created in the various factories of different divisions and business units.

Image 3.1. *ABB Low Voltage AC Drives product portfolio (ABB 2011).*

The case company is a Product Group (PG) of ABB called Low Power AC Drives. It belongs to the business unit (BU) of Low Voltage (LV) Drives which is part of the division of Discrete Automation and Motion. Other three business units in this division are Power Electronics & Medium Voltage Drives, Motors & Generators and Robots. The product portfolio of the Low Voltage Drives unit is presented in the image 3.1. Low Power AC manufactures the smaller half with a power range of 0-500 kW. ABB is the global market leader in LV drives and has a market share of about 18 %. The size of the low voltage drive markets was approximately 8 billion euros in 2010 and has faced outstanding growth during the past years.

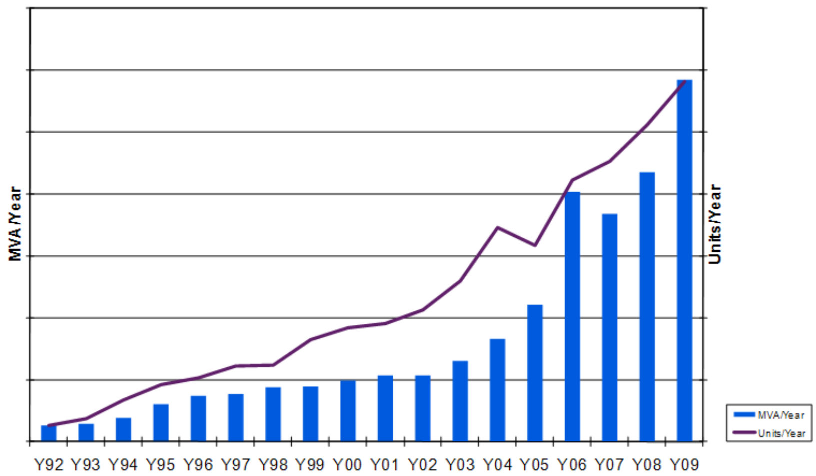

Figure 3.1. *The past sales growth of the BU LV Drives (ABB 2011).*

ABB manufactured its first DC (direct current) frequency converter in 1964. The production of the AC (alternating current) drives started 12 years later in 1976. Both products were developed and manufactured in Helsinki and the factory still is the global headquarters for the low voltage AC drives.

The frequency converters (drives) are typically used with electric motor applications such as pumps and fans. They change the frequency of the electricity which determines the motor's output speed and torque. Beside the fact that drives offer control, the biggest benefits are in energy efficiency. A drive is suitable either for AC or DC motor because the required components are different. (ABB 2010.)

3.1.1 The global manufacturing network

The case company can be defined as a real multinational enterprise although it is part of a bigger corporation. The question of whether the company operates according to the definition of global or transnational company is a bit complicated because it contains aspects of both alternatives. Eventually the global aspect can be seen slightly stronger because of the use of R&D centers, centralized top management and global products.

The case company shares common manufacturing facilities with the business unit's other product groups. The locations can be seen in the image 3.2. The head office with main design responsibility is located in Helsinki. It develops the majority of the products and related technologies. It is also typically the first factory to ramp the new products up.

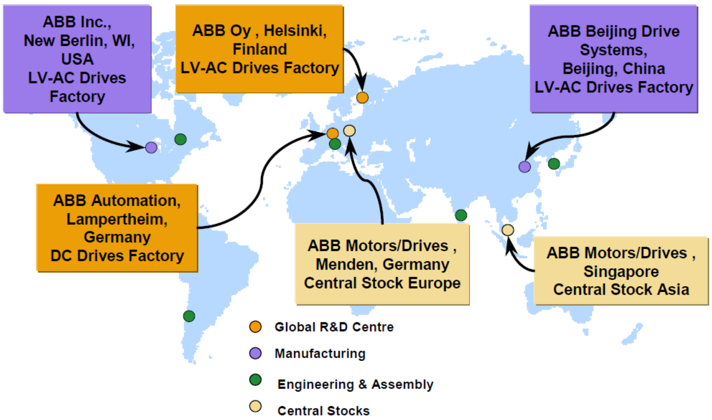

Image 3.2. *LV Drives production facilities (ABB 2011).*

The facts mentioned on the earlier page concern only the products and key processes. Meanwhile the international factories are very independent in the rest of the business activities. They assemble and test the products sold in their own regional areas. Beside of the manufacturing activities the sites have a full regional customer responsibility. They market and sell the products in their region and are responsible for offering an extensive service network in the area. The sites can also choose their own local suppliers. However, the lead site evaluates them first to assure their capability of supplying parts globally no matter if they are supposed to do it or not.

The past activities of the lead site define it as a hosting network player. However the strategic plans and the recent changes in the organization signify that the position is changing into an active network player. This means that the lead site is becoming more active inside and outside the own network to find the best practices and new innovations.

3.2 The local ramp-up process in the lead site

The case company had continuous production ramp-up problems some 10 years ago. Delays and problems resulting from the late engineering changes and poor documentation were typical (Melin 2004). The development efforts and recognition of difficulties has enabled to systematize and document the required procedures during the projects. This has helped the organization to understand better the importance of cooperation and communication. The biggest ramp-up related changes have been the introduction of specific ramp-up gate models and the broad use of cross-functional temporary teams (Melin 2004.)

These development efforts solved the biggest problems and took the ramp-up process to the next level. Nevertheless the most challenging problems remained. The literature defines these issues as very typical for the ramp-up situation. Earlier theses and project documentations are exploited to describe the current situation. Interviews are also used to recognize courses of action and to verify the findings.

3.2.1 Ramp-up definition in the case company

The pilots are the first visual result of the ramp-up. The company exploits α and β-pilots before increasing the production rate. These aim at assuring the design and manufacturability issues and preparing the manufacturing system for the production. The β-pilots have also another task. They test the readiness of the entire ERP-system and logistical processes by going through the entire order-to-delivery process.

Image 3.3. *The different pilot phases.*

The easiest method to describe the ramp-up process in the case company is to present it with similar volume curves as described in the part 2.1.2. It can be said that the ramp-up concept and vocabulary in the case company are a combination of all three examples presented in the literature review.

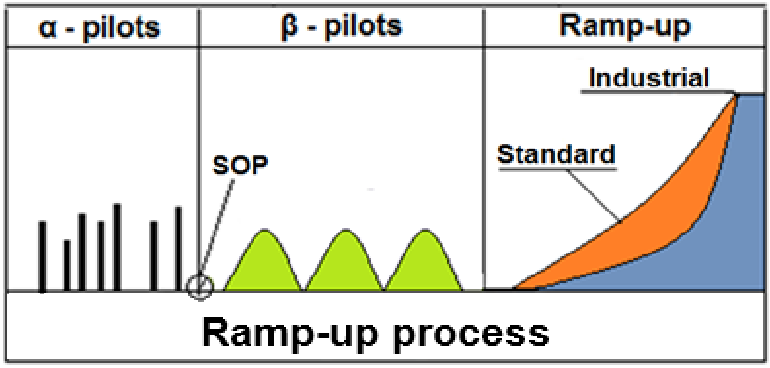

Image 3.4. *The ramp-up curves in the case company.*

What makes the curve in the image 3.4 a bit more complicated is the division of the products into two. The standard drives are made to stock while the ones called industrial drives are assembled to order. Despite of the different fulfillment strategies the overall manufacturing processes are relatively similar. Worth noticing is also that the ramp-up curves follow the slow motion strategy, which means slower concurrent ramp-up of the almost entire product family. This is due to the market requirements to offer a wide variation of products ever since the market launch.

The new products do not necessarily require significant changes in the production lines because of the large amount of manual work. Typically only the testing equipment and tools face radical changes. This also enables to exploit the alternative to assemble the old and new products concurrently in the same assembly lines. This overlapping production determines the workforce policy that follows the model (b) in the middle presented in the image 2.7. There is no need for much adjustment in the production rate so the number of employees stays relatively constant.

3.2.2 Sourcing and capacity usage

One of the biggest challenges today remains to be forecasting. The markets need time to evolve for the new products and product generations. The industrial customers prefer to purchase tested technology to shelter from any possible risk in quality or compatibility. The customers might also try to delay training their employees to the new generations and prefer to continue with the previous models. Training is a challenge for the sales department as well. As some parts and software might change during the piloting phases it is challenging to train the sales people before the product is ready. This is an obstacle that delays the start of sales.

These similar issues prevent the company from following the earlier suggestion to start full-scale production immediately. As there are not enough orders, the full rate in production cannot be rapidly achieved. This is something that delays learning and discovering the possible points of improvements. Although the assembly is not a big source of errors, it takes time to achieve reliability and high quality with different production volumes.

The engineering changes are a major challenge for production and material supply. Changes are the most typical during the piloting phases as the products are still being developed. The biggest reasons are design errors and new improvements. Although principally only quality related changes are allowed after the production is released, they continue to cause occasional problems during the ramp-up. The earlier thesis made for the company reveals that this was a big challenge in the past but the issue should be better recognized and controlled nowadays (Melin 2004).

Another challenge today is to assure the supplier preparedness for the ramp-up. This means capability to handle the changes and ability to respond to the volume increase. It should not be forgotten that the suppliers as well have to ramp-up their own manufacturing volumes. The company should somehow find and choose the companies with capabilities to serve as a world class partner.

3.2.3 The stage-gate models

Gate models have typically been extensively used in ABB and there are two different ones with 7-8 gates to manage the ramp-up period. The key idea is to force the organization to close and freeze the specification and design issues and continue further to the next phase. As a phase is finished and the decision point (gate) is reached, the steering group evaluates the current status. During the gate reviews the project's sponsor decides whether the phase is ready and the gate can be closed, does the phase need rework or is it better to terminate the entire project. The fourth alternative is to put the project on hold. This could happen if the resources are needed elsewhere or if the general technology is not ready yet.

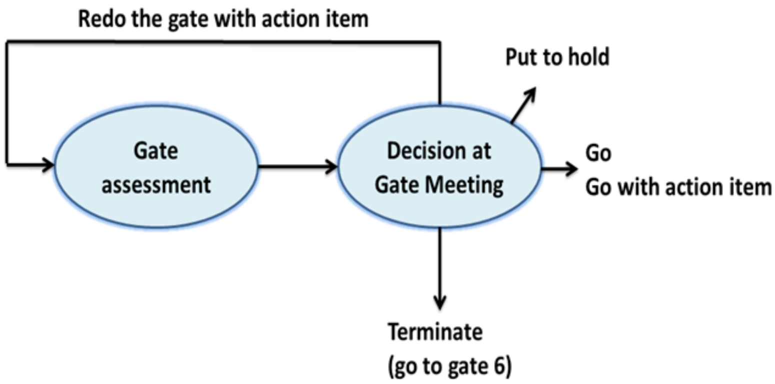

Image 3.5. *What happens in each gate (ABB 2009).*

The gate model used in the first ramp-up covers the entire NPI chain since the vision until the production is handed over to the line organization. It includes an additional list of ramp-up tasks, which helps the ramp-up team to focus better on production start-up related issues. (ABB 2007.)

Table 3.1. *The stages and gates in the NPI model (ABB 2009).*

The NPI model	
Gate 0	Start project
Gate 1	Start planning
Gate 2	Start execution
Gate 3	Confirm execution
Gate 4	Release product
Gate 5	Start introduction
Gate 6	Close project
Gate 7	Retrospective investigation of the project

The gate names presented in the table 3.1 are only the top of the iceberg. The models are extensive instructions of what should be done and when. They define the required teams and specify the functional members that should be involved. The most visual part is a task list that orders the assignments by time. It facilitates the management by presenting the status of the tasks and the person responsible. The models also include instructions how to control risks and manage costs. (ABB 2007.)

Literally ramp-up means only the gates following the product development phase. In the NPI model this means approximately the phases 5 and 6. However a successful ramp-up needs to be prepared much earlier as the product and the facilities need to be ready before the volume is ramped up. As mentioned in the literature review, these preparatory tasks practically determine the final ramp-up success. To understand the models better from the ramp-up’s point of view, each phase of the NPI-model is described generally to improve understanding of the activities involved. (ABB 2007.)

- The stages 0-2 gather and analyze information about the business environment and requirements for the new product and project.
- The confirm execution stage reviews the project benefits and defines the product specifications. The stage is also the beginning of the ramp-up project.
- The stage 4 contains ramp-up planning and preparative tasks to enable the volume production. The product design should be ready for introduction.
- The release product stage fine tunes the production system and improves the supplier quality and product design with the help of pilot batches.
- The gate 6 is when the volume is ramped up. After this gate the production rate should have reached the targets and the product design should be final.
- Finally, the success of the project is evaluated with calculations and analyzes.

3.2.4 Management and control

The company establishes temporary teams both for the NPI project and for the ramp-up process according to the decision models. The NPI project has a dedicated project manager that leads the entire product family from the design phase until the volume production takes place. The project team consists of representatives from various functions. (ABB 2007.)

The ramp-up manager has an extensive job description and is in charge of the ramp-up success as a whole. The team is cross-functional and the lineup depends on the size of the project. The team structure is a combination of light and heavy weight organizations. The used structure depends on the complexity of the situation and therefore it cannot be defined whether the manager and the members work either full time or only part time. (ABB 2009.)

The gate models offer standardized metrics to monitor the process and suggest using the following indicators that are listed below. The ramp-up projects are different so the team can add more measures or replace these items with more suitable ones if necessary. (ABB 2009.)

- Actual production volume versus planned
- Time to process stability
  - OTD (On Time Delivery) at the target level
  - FPY (First Pass Yield) at the target level
  - Weekly production compared to available capacity at the target level
- Number of engineering change orders between the gates 4-6

The characteristics of the production have a result that these indicators cannot be described perfectly suitable for the entire ramp-up process. They might give either irrelevant information during the pilot phases or do not motivate enough to do right things. However they are suitable if the full volume needs to be achieved rapidly.

3.3 Global product transfers and ramp-ups

The case company has an extensive and long history in product transfers. During the past decade it has established several new factories around the world and transferred stable developed products to these sites. These transfers have been relatively separate from the network's point of view and the volumes have increased radically since the initial ramp-ups.

The international ramp-ups are normally shorter and more compact than the earlier described local process in Helsinki. In the context of product transfers the development phase is finished and the number of engineering changes is radically lower. Therefore the sister sites can concentrate more on building the production environment and developing the subprocesses and phases involved in the order-delivery process. After the environment is built the regional factories can focus on learning the processes and improving the production quality to respond to the increasing volumes.

3.3.1 The global ramp-up process

The earlier presented NPI gate model has not been used for these international projects. Instead there is another model that has been developed especially for the product transfers and for ramping up new or upgraded production lines. The model's tasks and questions are more operations related instead of the aspect of product development in the NPI-model. The transfer model is currently being updated so there is no need for studying it more carefully in this thesis. The more important issue here is to consider how the tasks described in the transfer model are executed in practice and which areas cause the biggest challenges.

Each line and site is specific and the production capacities vary radically between the different locations. Therefore no simple copy-paste solution as presented in the Intel and Ericsson-models is currently being used to transfer the high volume products. Only some key manufacturing processes such as the testing procedures and joining processes are or are planned to be standardized to assure global quality.

In this case the ramp-ups with transferred products are more about adapting the earlier developed processes into certain environments. The assembly work is done according to the work instructions but the equipment and the supporting processes can vary. The crucial barriers for more extensive standardization are the long life cycle of the products and the variation of the production environments. The biggest challenge is that the production volumes are very different depending on the location. If the production line and production processes cannot be standardized what prevents to standardize the ramp-up process? This is why the gate models are being used. They standardize the ramp-up phases no matter who is in charge as a project manager.

Yet the ramp-up process can only be standardized until a certain level. This is because the ramp-ups are so dependent on two issues that are the people involved and volume forecasts. The major role of the people has also an impact on the fact that the cultural differences are a very typical cause for problems. Every project has to be adapted to be suitable for the environment at stake.

Depending on the extensiveness each transfer project can take from 6 up to 24 months. The initial ramp-ups can be very long lasting projects so occasionally some of the transfers need to be started before the product design is entirely finished. This is a typical reason for the challenges and difficulties. Although the product is at the minimum relatively ready, the transfer ramp-ups include both α and β-pilot phases. The reason is the need to test and prepare new localized suppliers, assure the line functionality and to offer learning opportunities for the assembly workers.

Although the high volume products are produced in site specific lines, the case company has experiences from the copy-paste method as well. For the late configured products there is a production concept available that is relative similar in every location. This includes the line lay-out, equipment and assembly tasks. These production lines of late configuration are relative short and include only final configuration with testing and software download. This is a good and relatively simple method to start manufacturing in new locations. This is what it means when a site has engineering and assembly operations in the image 3.2.

The interviews revealed that the transfer of ERP-information is a major source of work in today’s transfers. The data has to be transferred and added semiautomatically so it is slow and contains risks of errors. The transfer itself cannot be described as a problem instead it is just a major part of the project. Typically the importance of the ERP-systems during the ramp-up is not so visual because the systems normally work as they are supposed to. The biggest problems arise if the systems are not the same or compatible between the different sites which might cause problems in the flow of information. This can lead to old and wrong information concerning the assembled parts and tasks as the changes will not be updated automatically.

In general the IT-systems contain no such issues that should be studied here more detailed. There is a target to unify global ERP data and copy the information to the local sites. What every site should do is to define the right parameters and material handling information. There is also a development project to unify the ERP base information by creating master data databases that would be used globally. This is expected to assure that the data is similar and up-to-date everywhere. It should also reduce the need for manual transfer of data.

3.3.2 Engineering change orders

A typical volume ramp-up in the receiving site begins after the lead factory has reached enough volume to test and fix the possible problems. The product design can therefore be described relatively finished for volume production and the need for engineering changes is much lower than during the first ramp-up. Naturally the occasional changes can have an influence on the preparative work but the biggest difficulties can be avoided. Although the design is ready there still is a need for pilot production in every ramp-up.

The interviews among the staff involved in the ramp-ups reveal that the engineering change orders are not a big problem during the transfer as long as they are documented well and the changes do not have an effect on the products that were manufactured earlier. There is a specific process how to conduct all the needed tasks. As mentioned earlier a well-functioning ERP-system is a major enabler. It helps the use of the latest information, prepare for the changes and to manage the material flow during the changes.

The biggest problem in the changes is that the manufacturing staff might not read the attached instructions carefully enough, which might lead into general confusion. The engineering change orders taking place after the start of production are typically minor and do not cause severe actions. However the successful change requires preparation, information transfer and activities according to the given instructions. If some of these fail the change can cause major difficulties.

3.3.3 Supplier involvement during ramp-up

The sourcing process is already conducted according to the methods described in the literature review. First each part is classified according to the risks and criticality. The decision whether to localize or not is made with the help of this classification. If the part benefits from local suppliers involvement, the sourcing process is handled according to the instruction that have been defined for each class. The extensiveness of the sourcing process and the need for approvals depends on the classification.

The company uses parallel suppliers to reduce the risks of stoppages in material supply whenever it is possible and reasonable. The supplier localization process in the transfer related ramp-ups is currently under development. The new solution should follow the suggested method to use new suppliers during the piloting phases. The reason is to train the localized suppliers to respond to the needs in quality and procedures. The sites might also continue using the old suppliers at first and approve new supplier later on depending on the current situation. This alternative is often used due to the lack of time and resources. The entire business unit shares the suppliers and a common sourcing organization. Therefore the suppliers can be described as relatively trusted and familiar.

The challenges with the localized suppliers are typical for sourcing. The problems to respond to the fluctuating demand and the communication about the changes is a notable difficulty. The alternative to use other global suppliers in parallel reduces the risk of stoppages in supply. Yet the increasing amount of suppliers makes the communication concerning the engineering changes a bit more complicated and demanding.

A few interviewees pointed out that material supply related problems have been a major challenge during the earlier transfers. Some on the other hand told that material supply is not a big concern. Therefore these logistical problems can be seen very case related depending on the project size and environment. An upgrade project is much easier compared to a one with a new product family in a relatively new factory location. A typical deviation has been the supplier’s inability to deliver the materials on time. Quality related issues have been a challenge as well.

The difficulty to make forecasts and manage stock levels is something that is a very common problem both in the first ramp-up and during the following ones. Typically the expectations for the sales growth are too positive which leads to excessive stock levels and capacity. The forecasting problem can cause two challenging situations. First there is the situation where the market demand is below the expectations and the prepared production capacity is too high and needs to be adjusted to manage costs. This changes the shape of the entire ramp-up curve.

The increase in the market demand is often sudden which can lead into problems in on time deliveries because of unpreparedness in stock and capacity. As the ramp-up curve is modified it is difficult to respond to the demand if it eventually turns out to be as planned. Similar forecasting difficulties were observed in the earlier similar ramp-up thesis made for the case company (Melin 2004).

3.3.4 The ramp-up organization

The company has established global ramp-up manager positions to manage the ramp-up process in the lead site and to coordinate the transfers to other locations. The project organization can be described as light weight because of the members’ parallel functional roles. The role of the global ramp-up personnel is to coordinate and support the ramp-ups in the sister sites. This enables the longer term organizational learning and helps avoiding the replication of the most typical problems.

In the future each site is supposed to have a relatively similar local ramp-up team to work as a mirror organization for the global ramp-up team. This should make it easier to find the right counterpart from each site. Eventually the local organizations are responsible for making the line development and system implementation efforts.

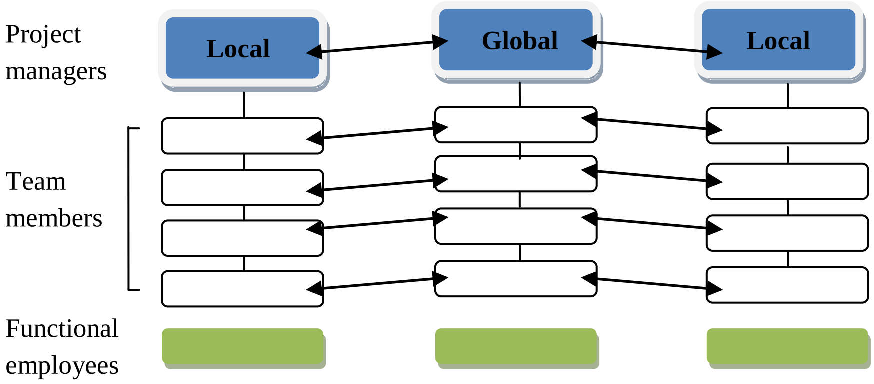

Image 3.6. *The current ramp-up network with the connections.*

The transfers and the overall management have been very centralized and currently there is not much cooperation between the sister sites during the transfer and ramp-up projects. The transfers can be seen more as a relationship between the global lead site and the local receiver site. Naturally more significant cross-network cooperation could be beneficial especially for the transfer of production innovations. On the other hand this could mean more confusion as no one would control the integration and operational activities in the network.

What is important to understand is that there are no plans to develop any clear and strict ramp-up command roles between the regional factory and the lead site. The top management is located in Helsinki, but still the idea of the management activities during the ramp-ups is coordination and support. In other words the lead site should help and support the sister sites to ramp-up their own production.

3.3.5 The methods used for information and knowledge transfer

Information and knowledge transfers are some of the main challenges during ramp-ups. This was highlighted both in the literature and in the interviews made for the employees. The situation is more challenging in the international projects as team members are located in different countries. Information technology is the key enabler to solve this challenge but the need for real interaction should not be forgotten.

It was said by an experienced project manager that the collaboration at the beginning is more valuable than later on. An early contact makes all communication easier and more natural while the ones made during the later stages do not have time to evolve into a valuable relationship. Similarly the people would benefit from the visits to other sites to understand the different environments. They would also enable project members to meet the project counterparts in their real work environment. Similar issues were described in the literature. The personal relationships take time to evolve and without early personal contact the communication and cooperation might never become efficient.

A very important tool to improve cooperation is a successful face-to-face kick-off meeting. According to an interviewee's experiences it should include only the project members that really are involved in the ramp-up and avoid big audiences of people that have no major role in the project. The people should also know their role as early as possible. The roles for the members should be defined already before the first meeting. Even a short definition is enough to give the members some information about their position in the future project. This issue is well known in the company and the project managers already try to inform about the roles as early as possible.

Virtual communication is the most important method to transfer general information. At the moment it means mostly e-mails, chats and calls. There is also a Microsoft SharePoint portal where all the files and documents such as work instructions and meeting minutes are uploaded. During this thesis it was easy to notice the difficulty to find the right people and perceive visually the network of people and functions involved in the current or earlier project. In addition the documents concerning the lessons learned in the earlier projects are across the field in the own folders of the different projects and therefore not easily available for the use of other managers.

Even this challenge is currently facing a development project and the target is to create a SharePoint portal that would be used by all the people involved in the ramp-ups. The need to create a visual network of people has also been noticed and is part of the development plans. The portal is planned to include photos and information about the roles in different projects to enable and improve the global communication.

The use of visiting employees is another important method to transfer tacit knowledge to regional locations. The lead site has the best experience and the most stable processes and therefore it is the best place for the trainings. The transfer can be seen two folded. First there is the silent knowledge needed during the preparative phase. This is used to create and develop the manufacturing environment such as designing the factory functionality or configuring the IT-systems. The second transfer is needed for the assembly workers who need to learn the work phases and processes to put the product together.

Training eases the start of the production by improving problem solving and offering efficient practices and methods to work. The literature states that the right people should be sent to other sites to learn the processes. However the right people is difficult to define and there are alternatives to choose from. The right people might mean managers, engineers and assembly workers. There is a need for a compromise that balances the costs and benefits. The best experiences in the company are from smaller teaching groups. Although it is difficult to define whether the group should include workers or engineers as there are positive experiences from both alternatives. The solution depends on the situation and the complexity of the transfer.

3.3.6 Measures and general targets

There would be a need for better performance indicators that would report the ramp-up status and the readiness for the volume increase during the preparative phases. The measures should offer information how the workers have learned the new processes and the availability of materials for the volume increase. In other words the indicators should present the status of the system before the production is released.

A suggestion given by a ramp-up manager was to measure the assembly or lead time and create a learning curve to follow up the development. The manager had noticed relatively good predictability and results with this measure. The biggest challenge with this indicator is the need for orders. However even with a minor load it is possible to notice the systematic development. A similar method was found earlier from the literature (Almgren 2000). The Almgren's example compared the realized labor hours and material costs to the set standard. According to the interviewee, the longer term measures could even bring information about the amount of production required to stabilize the processes. This could help the future ramp-up planning.

There is no recent and helpful information available concerning the metrics in the earlier ramp-ups that could be studied more detailed in this thesis. This can be seen as one major target of improvement. The earlier presented Intel case offered an idea of making each ramp-up a battle to improve the earlier one. Naturally this cannot be considered realistic when the information is not available.

Currently there are no clear targets to pursue during the transfer ramp-ups. The employees would need certain objectives and meters which would show the improvements and motivate to do right things. Every function shares some own objectives but the big picture is a bit blurred. The lack of company-wide targets can be seen resulting in weaknesses in the cooperation between the different functions.

3.3.7 Collecting the experiences from the earlier ramp-ups

One of the key objectives of this thesis was to collect feedback and ramp-up experiences from the entire organization. The seven questions of the inquiry listed below were formed to offer clear answers for the most interesting topics.

1. How would you characterize a successful or ideal ramp-up?
2. What has worked well in ramp-ups?
3. What are the biggest challenges you have encountered in ramp-ups?
4. What significant challenges remain unresolved?
5. What actions have you taken or planned to improve ramp-ups?
6. What support would you desire from PG (Product Group) Low Power AC?
7. Your free feedback

The feedback questionnaire was sent to people across different functions both in the lead site and in the international factories involved in the earlier ramp-up projects. It was designed so that it would be fast and simple to fill. The idea of the inquiry and the questions was not only to find the issues that require development but also good local practices that could be used in other factories as well. Another objective was to gather the factors that would define the ramp-up as successful. This is because in the case company’s context the production quality and the length of the ramp-up are not sufficient targets and therefore some other definitions are needed.

3.3.8 The key results from the inquiry and interviews

Part of the answers came written via e-mail, some were handed over and the rest were collected in interviews where the same form was used with some defining additions. The answer percentage was only moderate despite of the shortness of the questionnaire and fifteen out of forty-five relevant stakeholders replied. Nonetheless, the answers offer valuable information about the opinions and experiences.

The results were divided into two by the source. What made the questionnaire a bit difficult was the difference between the situations in the first ramp-up in Helsinki and transfer projects in the sister sites. The initial ramp-up in the lead site suffers especially from the difficulties caused by the R&D project. Meanwhile, the challenges in the transfer can be seen a bit different. Altogether, the answers enlighten the difference between these two situations very well.

There were two questions that were especially interesting. First it was important to receive opinions to determine a definition for a successful ramp-up. Secondly a collection of typical difficulties is very valuable in problem solving as the solutions are being developed. In addition the question number six gave important information to consider the role of the global cooperation and how to form the organization structure. The most important observations from each question are explained next.

How would you characterize a successful or ideal ramp-up in your organization?
The respondents stressed the importance to follow the project plan and create capacity according to the forecast. It is important to notice that this was equally highlighted across the company. It was also written that successful planning means that no new revisions are made to the plans. The typical success factors mentioned by the personnel in regional sites were communication and collaboration.

Other subjects repeated more than once were quality in all operations, forecasting and general scheduling. An interesting contrast between the opinions of lead and sister sites can be seen. Various Finns mentioned the challenges in forecasts and schedules, whereas the frequency of sort answers among the personnel from the regional factories was radically lower.

What has worked well in ramp-ups?

The target of this question was to receive potential best practices and receive feedback about the earlier experiences. Fewer answers were received compared to the other questions but some key points can be noticed. The earlier development efforts such as the development of ramp-up teams and transfer models can be seen relatively successful. Especially the answers from the sister sites were either cooperation or project management related and many gave positive feedback about the benefits resulting from the cross-functional and organizational communication.

What are the biggest challenges you have encountered in ramp-ups?

The biggest problems at the earlier stages of a ramp-up are poor material quality, design changes and lack of customer orders causing high inventory levels. As the volumes finally rise the excess inventory transforms into lack of raw materials. This is due to the fact that sometimes low customer demand leads into revised forecasts causing incapability to respond to the rising manufacturing volumes. As the suppliers do not trust the forecasts it often causes problems for the entire material supply.

Other important issues were the challenges in communication and collaboration. These issues were mentioned by both groups. The employees in the lead site had difficulties with the communication between the different functions while the people in the sister factories had faced challenges in global collaboration and lacked project resources. The amount of work related to the information systems was mentioned by three parties. Two of them have the latest experiences from the transfers so it can be described as a key challenge of the future transfers and might require more resources and attention.

What significant challenges remain unresolved?

Many answers were given but there were no specific issues that could be particularly emphasized beside of the difficulties in forecasting. Some interesting suggestions were also given and these are discussed more in the later sections. An experienced ramp-up manager described his experiences so that the solutions are typically known but there is a lack of budget or resources. Despite of that many important single issues came up that could be described as an objective for the newly established global ramp-up organization.

- Define the need for the resources and help to provide them globally.
- Offer information concerning budgets and schedules.
- Offer a big picture about other projects and keep relevant people up-to-date.
- Assure input availability before the project kick-off.
- The flow of practices should be better so offer support from the sister sites.
- The ramp-up knowledge should be preserved somehow in the organization.
- The organization should assure the involvement of the project members.

What actions have you taken or planned to improve ramp-ups?
The target here was to collect good practices and many were also received. It is not possible to make a short list so the most interesting ones are simply listed below.

Lead site
- Localize the supply of some of the parts later on to save time and resources.
- Give as realistic ramp-up forecast as possible.
- We formed cross functional ramp-up teams.
- We included ramp-up issues in product development process and projects.
- Continuous improvement of cooperation between different functions.
- Open communication to suppliers.
- Create plan A and plan B for every uncertain issue to reduce the effects of the problems.
- A good solution is to implement the easiest part of the project first (easier products). These solutions can often be used for the next phases, which has saved time later on.
- A focus on the details is important, the plans and guidelines should be made quickly.
- We defined the ramp-up process.
- Pushing and supporting R&D for alternative approvals already in the design phase.
- Feedback for R&D projects regarding optimistic volume planning for ramp-up.
- Get early commitment from the management that two supplier policy will be implemented in volume production.
- Formed special task forces to get e.g. product data in ERP system.

Regional factories
- Keeping buffer in hand, in case of any uncertain risk or delay.
- SOP-project is the only solution for the forecasting.
- Monthly PGU review: Solve and make decisions based on monthly report.
- We received training in the production line in Finland during the project.
- The Finnish members supported well in building the line and during periodic visits.
- GPL and GPE meetings are useful forums.
- Risk analysis and set key obstacles.
- Keeping communication and follow-up.
- Ranking priority and due time.
- Top management involvement.
- PM gives monthly brief project report with lights telling the current situation, which discloses the project situation and major obstacles.
- Enhance follow-up meetings to really happen.
- Before implementation, we have several review meetings to discuss new layout and processes to assure the efficiency of the plans and the capacity for the next 3 years.
- Document the line step-by-step with photos and video clips as a project reference.
- We trained our team regarding production flow and project ramp-up.
- We established the project team and arranged a brain storming to gather the inputs.
- The ramp-up model is used and the project team is established. Both work well.
- The SharePoint is a great way to communicate and share information.
- Smaller group meetings break down barriers and improve team environments. You still need the larger meetings, but the smaller ones are more essential.

What support would you desire from PG (Product Group) Low Power AC?
Similar issues as for earlier questions were mentioned. However it was typical that there is a need for some kind of specific information such as IT-issues, drawings or some other technical details from the lead site. The transfer of this information should be eased and improved. One method is to offer this information automatically at the initial stage or to improve the visibility how to get this information.

Some of the employees in the sister sites would see it valuable to have regular meetings with the lead site. Another mentioned issue was that the local factories would like to receive some information from the other regional factories as well. This information could include practices, new ideas and experienced field failures.

It can be underlined that many of the mentioned issues were communication or collaboration related. These could be partly fixed by improving the global flow of information and developing the relationships between the project members in the different locations. Forming a guide how to do this would enable to maintain the knowledge regarding a successful start-up process after the major projects.

3.3.9 Summary of the current situation

This chapter gives an extensive overview about the current ramp-up situations both locally and globally. It is easily noticeable that the earlier development efforts have been successful and it can be said that the ramp-up process is already in a relatively good state. There can be seen some issues that cause the majority of the challenges in the lead site. The biggest single issue is the unpredictability of the R&D projects and the challenge to forecast the sales before the full volume production is achieved. Typically the forecast have been too optimistic. The other interesting challenges are often related to collaboration, project input or IT.

The first two issues were already mentioned in the earlier thesis (Melin 2004) some 8 years ago and not much can be made to develop them. These problems can be seen unavoidable and typical for ramp-ups. They are also more typical for the first ramp-up. This thesis focuses especially on the global ramp-up process so it is more valuable to focus on the issues that could improve the global transfer projects.

It can be noticed that there are no obvious and simple problems that should and could be fixed easily. Instead of fixing something the suggested solutions should focus more on how to assure the success in the single transfers. The best concept would be to create a model how to organize the coordination and communication between the global management and the various transfer projects. An interesting suggestion given by a production development manager was to create a handbook of ramp-ups. A compact toolbox containing methods to improve the flow of information with the help of a standardized start-up process should be part of this manual.

4 CONCLUSIONS AND RECOMMENDATIONS

The initial research problem was to consider methods to improve the global ramp-ups. This problem can be seen two-folded. First there are the single ramp-ups and the need for improving the international project management. The other question is how these single projects should be managed in a coordinated way. It is important to understand that the critical activities defining the success of a ramp-up are those happening long before the volumes increase. The preparative work at the early stage practically determines the ability to increase the volumes according to the plan.

The target of the inquiry and interviews was to find factors that either assure the final success or cause the challenges. Not many specific problems were mentioned, but the importance of international communication and collaboration emerged constantly. The inquiry offered good practices as well but practically all of them are already being used in the company. Altogether, the received answers were the key driver and source of opinions behind the following recommendations.

Successful teams are typically characterized by six elements and the same factors can be attributed to international environments as well. Thus, one of the targets of the following recommendations is to offer methods to assure the realization of these issues. The ERP and PDM (Product Data Management) systems are key enablers too but they will not be discussed more detailed.

Table 4.1. *Six elements of a successful project team* (Clements & Gido 2009, p. 362).

Clear understanding of the project's objectives	Clear expectations of roles and responsibilities
A results orientation	High degree of collaboration and cooperation
Commitment to achieve the targets	High level of trust

The main suggestion of this thesis is to offer tools to assure the integration and successful cross-cultural communication in global ramp-ups. The other key recommendation is to start using some of the methods of program management to coordinate the multi-project entity. Due to the reason that the case company already has a well-functioning organizational structure for ramp-ups, the presented ideas can be seen more as an alternative to back up the current solutions. In addition, this chapter presents a handful of observations that would require attention or some development efforts. These recommendations are only suggestions, and this thesis does not include the execution or more extensive documentation.

4.1 Tools to start international projects

A project start-up is not just about meeting the other members or creating a plan to execute the project. The target should also be to create strong relationships and consensus on the mutual objectives. An international start-up process resulting into a successful project outcome was described to take three times longer compared to a local one. Another aspect worth considering is the need for a global start-up. One of the suggested success factors in the literature was to create a sense of a global team and a mutual culture that encourages to share local challenges with colleagues.

A kick-off meeting is a critical event when creating a foundation for a project. Despite of its importance it should not overrun the rest of the activities involved in the start-up process. The following suggestions offer an example for a start-up when an international project with members unfamiliar to each other is established. Although the projects are different and the needs to assure the communication vary, it is beneficial to at least consider the use of these following steps to assure the success in international and cross-cultural cooperation. The suggested procedures include practices taking place before, during and after the start-up meeting.

4.1.1 Preparative start-up elements

A project team representing different cultures leads into a mix of habits and behavioural norms. A typical target is to create a global culture, but the cultural specific habits might come up at the latest when a person is stressed or busy. Cultural training is an often neglected practice, although it would be beneficial to understand how others manage conflicts and negotiate for example. Deeper understanding of the other culture could even improve motivation to work with other nationalities. The training could contain topics such as attitude towards hierarchy, time and feedback.

Interviews and stakeholder analysis mean interviewing the project members for assuring their motivation and level of commitment. The interviews could help mapping the existing relationships, tensions and missing links between the stake holders as well. The analysis gives a basis to consider the need for face-to-face meetings and to plan a strategy for stronger relationships. The interviews could also offer information covering for example the preferred communication method and personal skills including earlier work experience for back-up and illness situations.

4.1.2 Mutual face-to-face kick-off meeting

The kick-off meetings have typically been organized at the regional site due to the fact that these are locally executed projects and most of the stakeholders sit there. This is probably the right method but the benefits of visiting the lead site should be remembered and the following meeting for example should be organized there.

In addition to planning the project's execution the team should establish guidelines for the project. The American company Xerox has developed a model for this. It includes nine steps that should enhance and assure the future communication. This offers a good basis for the topics that should be covered by the meeting's agenda.

Table 4.2. *The team start-up model used by Xerox* (Fisher & Fisher 2001, p. 120).

1.	Form the team
2.	Communicate the vision
3.	Develop a mission statement
4.	Define goals
5.	Develop norms
6.	Develop roles
7.	Develop meeting processes
8.	Develop communication processes
9.	Develop work processes

An important part of a kick-off meeting is to agree on the issues presented in the table 4.2. The agreement should cover for example maximum response times in communication and procedures to manage conflicts or to make decisions. If this activity is neglected the operational norms practically evolve without control. This might end up in a successful outcome but there is a risk that members from different cultures cannot find mutual procedures, leading into conflicts or inefficient practices.

The project kick-off meeting includes sometimes an element called kick-off seminar, where a small group of people closely related to the project listen to each other's presentations somehow concerning the coming project. Every participant is supposed to be active in commenting the presentations of others. This should develop the relationships and offer new opinions and aspects for the presented topics.

4.1.3 Activities after the start-up

Virtual teams should meet regularly to maintain some level of communication and relationships. Practically these meetings mean video or telephone conferences. A typical opinion according to Fisher & Fisher (2001, p. 121) is that at least two face-to-face meetings should be organized after the start-up. These should take place in the middle and at the end of the project. The team should also celebrate whenever a milestone is achieved. Due to the distance a real party is typically not realism and therefore some creativity is needed to celebrate virtually. A simple example is to send celebration hats for the other members to be worn in the virtual meeting.

Coaching during the projects was often underlined in the project management related literature. This means supporting the project managers on their personal development and acting as a conversation partner in the ramp-up and management related topics. This could reinforce communication links and back up local execution projects.

4.2 Methods to add integration between the projects

The company's current global ramp-ups signify groups of locally executed projects. The personnel in the lead site (LS) not only execute the first ramp-up but also support and coordinate the local projects. This current concept works fine, but the questionnaire answers from the regional sites brought up a strong interest to have more collaboration with the rest of the ramp-up teams and to receive more information concerning the progress of the entire global ramp-up. The improved understanding of the entity and other projects would also help local ramp-up managers to align their execution better with the global objectives.

It should be remembered that global ramp-ups in this case do not mean just starting the production or increasing the volumes. Instead especially with new product generations the target should be to create a global manufacturing system for the coming years. The case company's present solution is very focused on achieving success in the single projects and it can be seen very well developed for this matter. Yet managing the entity has not been a similar concern so far and it is difficult to draw a visual description of the global ramp-up and its management.

The first task therefore is to generate a more specific definition for the global ramp-up. Currently it does not refer to a program or a project but more to a collective ramp-up process inside the NPI-project. The suggestion is to regard the first ramp-up more as part of the NPI-project, since it is very different in nature compared to the following ramp-ups in the sister sites. The following transfer projects could be gathered into a global transfer program and the global entity would be managed using a matrix structure coordinated by the global ramp-up manager.

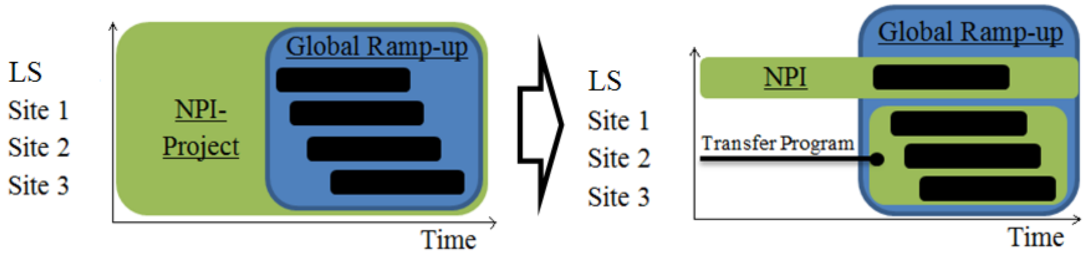

Image 4.1. *The old and the new definition for the term global ramp-up.*

The next image 4.2 offers an academic solution for these transfer programs. The theoretical program structure requires some adaptation due to the facts that the company has no Program Management Office (PMO) and the ramp-up organisation has established roles and names already. The presented program structure would not only offer an alternative for the organisation structure but also provide methods and tools to coordinate the similar projects more integrated and efficiently.

Although the images depict the program manager as a superior of the local project managers and the mirror team as an external organization, Binder (2007, p. 7) has defined the roles as follows: "Program manager is responsible for providing direction and guidance to the project managers, and may receive assistance from a Program Support Office." Yet, the mirror team could be seen belonging to the local project organisations, the members are virtual members sitting in the lead site and can thus be described as externals. Therefore the existence of the PSO can be seen justified.

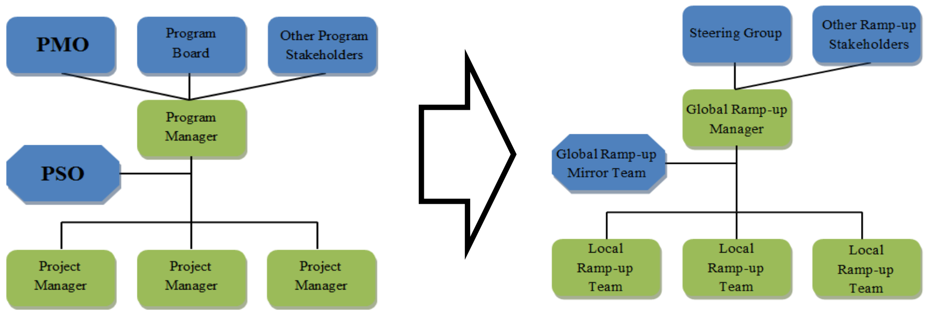

Image 4.2. *The program stakeholders* (Binder, p. 7) *and the adapted solution*.

The steering group would signify a group of directors from different factories defining the requirements, resources and schedules for the global ramp-up. The group should create the program strategy and define the pursued objectives. The function could offer the global ramp-up manager an extensive mandate and top management support to make heavier decisions. The global ramp-up managers for their part should focus on implementing the strategy and gaining program benefits by saving resources and by improving the final outcome and business results.

The global ramp-up procedures are currently being developed using workshops. The new idea is to expand the list of participants by adding members from the regional factories as well. The program specific procedures could be developed using program core teams that include the people such as local ramp-up managers and those forming the mirror team in the lead site. This could be a beneficial forum for discussions and to transfer ideas between the teams.

The global ramp-ups could be divided into work packages using the program work breakdown structure method. It could help noticing options to share solutions between the local projects. Dividing the projects this way could help defining the required resources and inputs in advance. The packages should be copied from one ramp-up to another using the rapid design transfer method signifying continuous improvement. Creating and evaluating the PWBS could even be described as a sort of a simulation especially if it includes the time perspective. However the best solution is probably to conduct the simulation or reality check together with the transfer model. The simulation should include testing the plans and schedules using risks and alternative scenarios.

Another new idea is to define a program specific communication plan. The importance of these plans is emphasized because of the need to improve the general communication. These plans would map the stakeholders with their information needs and specify how and when the required facts are supplied. It could also define how the global progress should be reported up and downwards in the organization.

4.3 Other observations

In addition to the two key recommendations some suggestions and conclusions for the observed single challenges are presented next with suitable solutions.

4.3.1 Ramp-up targets in the case company

It would be useful to underline the tactical role of the local projects. This means following the initial project plan and creating the manufacturing system according to the best forecasts available. Above all this would require unrevised plans throughout the project. These projects should be executed fast to save costs and resources.

Another target should be to execute the project in order to achieve a system responsive for the deviating demand. The easiest method is to use parallel suppliers since start. This should assure the material supply even during the increasing demand and quality defects. The company should also create and highlight a company-wide target and commitment to increase the volumes according to the initial forecast.

4.3.2 Information systems

Although ERP and IS related issues receive attention, the sufficient support and resources should be assured in the coming projects. It was mentioned that IS related development work tends to multiply during the projects. It is easy to imagine that the amount of this work will only increase in the future. The sufficient centralized support would assure to avoid possible delays and defects in the data transfer process and when implementing the production environment to the ERP and PDM systems.

4.3.3 A manual for ramp-ups

The literature does not offer any decent handbook for ramp-ups at the moment and the ramp-up knowledge in general can be described as relatively tacit and company specific. There are experienced managers that know the practices and procedures but what happens if they suddenly leave the company? It takes long to achieve the same level of expertise. The development manager of another product group presented his idea of creating a handbook including the knowledge of how to use the ramp-up models and what else should be involved. It could be a relatively extensive effort but one alternative is to create the manual for the entire business unit as a shared project. Other alternative is to create the handbook by establishing an internal wiki-project.

4.3.4 Methods to monitor ramp-up maturity

Defining the maturity of the product and processes at the earlier phases of the ramp-up is very challenging. Due to the company's low piloting volumes and short lead times in assembly, most of the theoretical indicators cannot be seen practical. Furthermore, defining the manufacturing system's maturity does not concern just the internal assembly processes. One of the biggest challenges is to assure suppliers' preparedness as well. This thesis cannot offer a solution for the latter but for own assembly processes the most suitable alternatives would be to monitor yield, summed assembly time or realized expenses compared to the standard cost.

4.3.5 New elements for the web portal

The contact information should be easily available in the shared web portal and include pictures and personal descriptions concerning the responsibilities, skills and experience. This is due to the large grid of stakeholders in global projects. The portal should also include the three elements mentioned in the questionnaire answers. These were the status, overall schedules and future plans of the entire global ramp-up. The new coming portal is supposed to contain at least some of these elements.

An alternative to create a sense of a team in the global ramp-up context is to use some virtual network application to gather the people and present images for example from the milestone celebrations. Wiki based documentation methods are also possible modern communication tools to create a sense of a community.

4.3.6 Best practice transfer using competence groups

The literature states that the transfer of best practices is normally a very laborious effort. When considering the methods for this, two important issues should be remembered. The first is the fact that it is easier to conduct the transfer before own solutions are created. This is because the biggest challenge in process transfers is that own practices are regarded better and more suitable than the ones created by someone else. The transfer could be easier if the own solutions had not been developed yet. The mutual strategy should be to develop the practices further and to offer the made improvements for the factories using the earlier versions.

Another aspect is the need for strong relationships and real interaction. An alternative to share the practices is to create teams and use virtual team spaces in the global web portal. To deepen the relationships, there should be some occasional real interaction as well. There could be groups to develop areas such as assembly, development, IT and layout and the teams could operate according to the ideas of competence groups to transfer solutions and ideas globally. Other alternative is to develop globally shared critical solutions using cross-functional and cross-cultural transnational teams.

5 SUMMARY

The topic of global manufacturing ramp-ups is becoming ever more important for all globally operating manufacturers as the future demands them to spread presence around the world. Companies are buying local businesses and establishing regional factories to serve their customers better and to lower the costs. Today even smaller businesses are under pressure to decentralize their manufacturing operations.

It is not reality any more producing only matured products in the new markets. Customers around the world demand the newest products and are also willing to pay premium for getting them. In addition, this globally mutual operation offers alternatives to increase efficiency with global standardization as well. Due to these aspects the products should be similar around the world, and be produced and distributed with an optimal balance of standardization and adaptation. These are the major trends that highlight the importance of the global manufacturing ramp-ups.

5.1 Theory and reality in the case company

Ramp-ups are always a great challenge because they involve confusion, delays and problems. The decisions should be quick, but due to the different objectives the decisions are rarely easy. As my supervisor summarized, there are mostly best compromises available. Three applicable ramp-up frameworks were found during this thesis. The one published first described ramp-up just as the phase of volume increase. Meanwhile the latest model used the term for the entire start-up process.

The main target was to focus on global ramp-ups. Factories always have a role in the network, which is very important when considering the required activities and procedures in ramp-up projects. What makes a global ramp-up different from the one in the lead site is the need for comparing the advantages of standardized and locally adapted solutions. The use of standardized processes stresses the need for transferring knowledge and information between different locations.

Problem solving is a crucial part of the ramp-up period, hence a great deal of the literature review focuses on disturbances and on methods to manage and solve them. The theory is relatively focused on auto and electronic industries and many of the found solutions are thus very industry specific. Another challenge with the theoretical findings is that the manufacturing grids in the ramp-up context are also typically considered as tightly knit networks of sites with similar volumes.

The ramp-up reality in the company is slightly different compared to the image portrayed by the literature. The case company has various independent factories around the world producing different volumes and having distinctive advantages. What is more, the company's products have relatively long life-cycles. Therefore it would not be the most appropriate alternative to follow the theory blindly. Altogether, most of the disturbances mentioned by the literature are very familiar in the case company but their mutual weighting is different. The literature highlighted for example sourcing as a big challenge during the ramp-up. Due to the company's strong focus on final assembly, the suppliers in this case can be seen even more significant for a project's success.

5.2 The main conclusions and recommendations

The ramp-up practices in the case company seemed to be at a very good level. Most of the observed challenges were so typical for the NPI projects that not much can be done for those with a single thesis. However the biggest solvable point of improvement was the global demand for better communication. This was highlighted both by the people in the lead site and in the regional factories. The lead site would require better cross-functional collaboration. Meanwhile, the sister sites asked for more support from the lead site and a possibility to communicate with the other regional factories as well.

The best method to improve the international communication is to offer practices and structures that could visualize the environment better and strengthen the cross-cultural relationships. The first issue that needs to be highlighted is that the only method for this is to increase the amount of real interaction. This should happen not only during the kick-off meeting but also regularly along the project's.

The recommendations suggest creating a standardized start-up procedure for the international projects. This should be done after the global ramp-up managers have gained some experience from testing the suggested practices. This thesis also highlights the importance of the ramp-up web portal for general communication. It was relatively easy to notice from the outside that contact information was often relatively difficult to find. The web portals could also include some new elements that are presented in the literature review.

Another beneficial improvement could be to improve the integration and cooperation between the local projects. This would enhance the global flow of ideas and practices in the network. The recommendations suggest some program management related methods for this.

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