TAMPERE UNIVERSITY OF TECHNOLOGY

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FRAMEWORK FOR INTEGRATING OFFSHORE DESIGN OFFICES

Master's Thesis

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ABSTRACT

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The goal of this Master's thesis was to find an integration framework and process between Cargotec Tampere's main design office and locally situated design offices. The problem had been that there was no defined process to integrate the local small offices with the main global office at Tampere. Without a defined process and tools it is difficult to achieve good efficiency from the start.

The thesis was made with qualitative constructive research methods. The three main research processes were literature review, interviews and two case studies inside Cargotec. For the literature review, three research areas were studied: global engineering networks, virtual teams and supplier integration. From those three areas a synthesis was developed, called the combined theoretical model for design office integration. The interviews covered approximately 15 different people. From the interviews the current situation of integration and the requirements for the practical framework were synthesized. The two case studies on Cargotec's design office in China and a daughter company, MacGregor, are based on interviews with managers, whose job it was to manage and develop offshored design offices. They are presented as individual evidence on the difficulties and lessons learned.

When researching and interviewing employees, it became clear that there were many problems with achieving good integration at Cargotec. First, there had to be a clear sense of what kind of capabilities the new office had. Second, what materials and training should Cargotec give to the new office to match the main office's capabilities? To improve the situation, an integration framework and three tools were created. The framework and tools are derived from the combined theoretical model. The framework consists of three phases: Survey, Sharing and Verification. The survey phase defines the needs for a new design office, maps and evaluates the capabilities of the prospective design office, and evaluates the offshoring risks. For this, the phase two tools, called current state analysis and risk assessment, were developed. The sharing phase defines and shares all the materials and other resources that the host design office would need to get to the same level with the main design office regarding software, network, skills, material and product knowledge. For this phase, an Excel-tool called the integration package was developed. The last phase, verification, is meant to verify the results of the sharing phase by giving the new design office a pilot task, which tests the new office's systems, knowledge and communication. The testing of the framework and its tools showed that they were mature enough to be used at Cargotec.

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TAMPEREEN TEKNILLINEN YLIOPISTO
Konstruktiotekniikan ja teollisuustalouden laitokset
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Tämän diplomityön tavoitteena oli löytää integraatioviitekehys ja siihen yhdistyvä prosessi Cargotec Tampereen ja uuden, muualla kuin Suomessa olevan, lokaalin toimiston välille. Ongelma oli, että Cargotecilla ei ollut määritettyä prosessia, jolla voidaan integroida uusi lokaali suunnittelutoimisto globaaliin suunnittelutoimistoon Tampereella. Ilman tätä integrointiprosessia ja siihen kuuluvia työkaluja, on hyvin vaikeaa saavuttaa suunnittelun tehokkuus heti alusta alkaen.

Tämä työ tehtiin kvalitatiivisella konstruktiivisella tutkimusmetodilla. Kolme päätutkimusprosessia olivat kirjallisuuskatsaus, haastattelut ja kaksi tapaustutkimusta. Kirjallisuuskatsauksessa tarkasteltiin kolmea tutkimusaluetta: globaalit suunnitteluverkostot, virtuaaliset tiimit ja toimittajaintegroituminen uusien tuotteiden kehityksessä. Näistä alueista tehtiin synteesillä teoreettinen malli, jonka nimi on yhdistetty teoreettinen malli suunnittelutoimistojen integroimiseen. Haastattelut kattoivat 15 eri henkilöä Cargotecin sisältä. Näistä haastatteluista johdettiin integraation nykytilanne ja vaatimukset uuteen käytännölliseen integroimisviitekehykseen. Kaksi tapaustutkimusta käsittelevät Cargotecin Kiinan suunnittelutoimistoa ja Suomessa sijaitsevaa tytäryhtiötä nimeltä MacGregor. Molemmat tapaukset esitetään omina todisteinaan integraation vaikeuksista ja opittavista asioista.

Integraation tehostamiseksi tulee ensinnäkin olla selvää, millaista suunnitteluosaamista uudella toimistolla on. Toiseksi, millaista materiaalia ja koulutusta Cargotecin pitäisi antaa uudelle lokaalille toimistolle, jotta sen kyvyt olisivat mahdollisimman lähellä Tampereen toimistoa. Tilanteen parantamiseksi kehitettiin integraatioviitekehys ja kolme työkalua. Viitekehys ja työkalut ovat johdettu yhdistetystä teoreettisesta mallista. Viitekehys sisältää kolme vaihetta: arviointi, jakaminen ja tarkistus. Arviointivaihe tutkii uuden lokaalin toimiston tarpeet, kartoittaa ja arvioi sen suunnittelukyvyt ja mahdolliset toimintariskit. Tähän vaiheeseen kehitettiin kaksi Excel-työkalua nimeltään nykytilan analyysi ja riskien arviointi. Jakamisvaihe määrittää kaiken sen materiaalin ja resurssit, joita uusi toimisto tulee tarvitsemaan saavuttaakseen pääsuunnittelutoimistoa vastaavan suunnittelulaadun tason ohjelmissa, tietoverkoissa, taidoissa ja tuotetiedossa. Jakamisvaiheeseen kehitettiin Excel-työkalu nimeltään integraatiopaketti. Viimeinen vaihe, tarkistus, kehitettiin varmistamaan edellisten kahden työkalun tehon antamalla uudelle toimistolle pilottitehtävä. Viitekehyksen ja työkalujen testaus osoitti, että ne ovat tarpeeksi pitkälle kehitettyjä, jotta ne voidaan ottaa käyttöön Cargotecissa.

PREFACE

I want to thank Mika Haapalainen and Pasi Rantanen for selecting me to do this very interesting assignment and for their continuous support. Haapalainen worked as my thesis supervisor and I have only high praise for him for guiding and assisting me. I want to thank my supervising professors at TUT, Prof. Miia Martinsuo and Prof. Erno Keskinen, for their mind opening comments and support for the work. I also want to thank all the interviewees who were willing to sit down with me and talk about their work and how they see global operations at Cargotec.
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Jukka Vesala, 5.11.2010, Tampere

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ABBREVIATIONS AND NOTATION

BOM	Bill of materials
CDO	China’s design office, Cargotec's design office near Shanghai in China
CEI	Cargotec Engineering India, Cargotec's design office in India
CROL	Customer relationship on-line, MacGregor uses CROL for evaluating design offices and its personnel
CSA	Current state analysis is a tool that Cargotec can use to evaluate possible new LEOs
GEO	Global engineering office, e.g. Tampere unit
IP	Integration package, which is an Excel-document listing all the suggested things that the IC should take care of when setting up a new LEO
Key user	Is a person who is responsible for delivering and checking design work which comes from LEOs. She/he is the "spokesperson" of the design office.
LEO	Local engineering office, e.g. Cargotec's China and India design units
MAU	Multi assembly unit, Cargotec's name for manufacturing unit
NPD	New product development
PDM	Product data management
RTG	Rubber tired gantry crane, a harbour logistics machine
SFS	Finnish standardization company
SIS	Swedish Standards Institute
VPN	Virtual private network
VT	Virtual team

1. INTRODUCTION

1.1. Goal

The main aim of this Master's thesis is to find an integration framework and process between Cargotec Tampere's main design office and locally situated design offices. The problem has been that there is no defined process to integrate the local, small offices with the main, global office at Tampere. Without a defined process and tools it is difficult to achieve good efficiency from the start.

Integration here means the process of how to be sure that the office is capable of doing the tasks that are required, what information should be given to the local office so that they can do the task and what kind of interaction models between actors should be put in place in order to achieve efficiency from the beginning. After integration, the main design office at Cargotec and its local design offices around the world should have almost the same information and resources. The goal is to get the new design office in line with the global office.

As for the areas of research and fields of interest, the integration of design offices combines offshoring and inshoring policies, engineering and project management, cultural awareness issues, global HR, globally distributed engineering and change management. All of these will be dealt with in the literature section.

There are three concrete outcomes from the research. The first is an integration framework for the overall process of attaching new design offices to Cargotec's operations in Tampere. This focuses on the interactions (e.g. communication or exchange of objects) between different actors on both sides in the beginning of the relationship. The second is a tool, current state analysis (an Excel list), to evaluate possible design offices abroad or in Finland and assess whether they are capable enough of doing design for Cargotec. The third is also a tool, an integration package (an Excel list), which is meant to provide a general tool for making a good start in the new design office in order to start working at full speed right from the beginning.

The research problem concerns developing an integration model and tools for offshore design offices.

The three most important research questions are: 1. What kind of integration model is the most efficient for Cargotec in the short and long-term? 2. What kinds of skills, knowledge and processes are needed in the local design offices to make them capable of doing design work for the global design office? 3. What kind of resources, help or material does the local design office need in order to integrate faster and better to the global design operations?

1.2. Purpose of this thesis

This thesis was done because Cargotec does not have a written-down process or a model for integrating offshore design offices. They need this to reduce wasted time and effort at both locations. From a broader perspective, the offshoring of design operations is a growing phenomenon. Small countries especially small ones like Finland, should not think that they can produce the best high-technology global products only with local knowledge or resources. They need to tap into the global talent pool and do design and R&D near to the customers. Furthermore, all Western companies need to reduce their costs, as competition from emerging countries, such as China and India, can manufacture good quality products with lower costs. In the RTG product field, the Chinese company, ZPMC, is a good example of this. In the second chapter of this thesis, there will be a more in-depth examination of design offshore motivation.

1.3. Scope

Design partnership, or even a shorter use of an offshore design office, can be seen as a process which starts from evaluation of the office. The next phases of the process are integration in order to understand the design case and products, continuous design work, and finally the dissolution of the partnership. The focus of the thesis is on the first two parts: evaluation and integration. Integration stops when it is seen that the outside design office has understood the context of the partnership and proved with a pilot design case that it can perform well and that there are no major problems with practical matters, e.g. access rights or with common tools. Thus, this thesis focuses very strictly on the *beginning* of the offshoring process. This is why the thesis does not look at other aspects of offshoring theory. Also, the thesis will not examine the personal or country aspects of offshoring. It focuses purely on the office level.

At company level, the scope of the thesis is a future design office of Cargotec in Poland and the scope in terms of the product level is the rubber tired gantry crane (RTG). Thus, offshoring manufacturing is not discussed at all because design operations are very different to it. When talking about design, R&D is not included. The focus is on customer project design, which is much more structured and standardized. Customer project design is basically a semi-structured process. It starts when a customer decides to buy a machine and ends when different designers have completed their design of customer specific features in the product. Although the focus is on the customer design, articles and data from studies carried out in the R&D context are used. R&D is different to customer project design, but project design can be seen as being part of R&D, because R&D is more complex than project design. As we will see in the second chapter, offshoring is very different to outsourcing. Therefore, outsourcing data or articles are not used without explaining why and in what parts they are used. This is because they are based on different assumptions.

1.4. Research methods

In this thesis a qualitative constructive research method is used. The analysis is based on past research, the surrounding context, summarized data and a synthesis of these. The main three research processes are literature review, case studies and interviews with Cargotec personnel. For the literature research almost exclusively Internet based search-engines for scientific publishing, e.g. Nelliportaali of Tampere University of Technology and Google Scholar have been used. Most of the company and product information was gathered from designers and managers and verified by cross-checking and company materials. The two case studies on Cargotec’s design office in China and a daughter company, MacGregor, are based on interviews with managers, whose job is to manage and develop offshored design offices. These are presented as individual evidence of the difficulties and lessons learned. The China design office is an exciting example of the kinds of things that can go wrong when offshoring design operations. The MacGregor case shows the company´s extensive history of doing offshore design and presents some examples of good practice.

The interviewees in Tampere were selected based on key personnel in the subject area and according to the needs that arose from the other interviews. A core group was selected which had first-hand knowledge and experience of the topic. These were mainly customer project designers, specialists or managers. The interviews were mainly informal and had mostly open-ended questions. However, two topics were always covered in the interviews: the experiences and needs of designers who have been in contact with Cargotec’s design offices in India or in China. Approximately 15 different people were interviewed, and usually at least twice. The first round of interviews usually lasted about one and a half hours, and the second round from 30 minutes to an hour. In every interview, the interviewee was first asked if he/she would like to tell something about him/herself. Then the present findings and results were presented to the interviewee, who was then asked questions about the topic. The researcher tried to get detailed information about the subject the interviewee was specialized in, but also wider information which could be used to broaden understanding and to select the next interviewee. Extensive notes were always taken.

After every interview, the answers and viewpoints were inputted to the thesis or to the tools. All of the main conclusions made in this thesis are from a synthesis of the results, from my own experience working at Cargotec, the literature findings and the interviews.

1.5. Structure of the work

The thesis starts with a literature review. The first two issues that are researched are what offshoring is and why companies do it. This is important in order to verify the terminology and to find the reason why offshoring design offices are set up in the first place. After this three models for transitioning local operations to global ones are presented. The first model is about transition from local to global design operations, the second a model from virtual team literature, and the third is about success factors in supplier integration. After presentation of the three models I create my own, which is a synthesis of the three models with added concepts from other areas. This model will be the framework for the results section and especially for the proposed solutions. At the end of the literature review, I look at different risks in offshoring. It is important to estimate the risks in the beginning of offshoring and transition.

After the literature review, the context of design operations at RTG design is presented. This will give the reader a sense of the current situation and the design tasks and difficulties. The whole chapter is based on the interviews carried out in Cargotec.

The fourth chapter presents the results and findings on what is required in order to form a successful model process and tools for design office integration at Cargotec. Firstly, the current state of integration at Cargotec Tampere is presented, followed secondly by a case study regarding what things went wrong when setting up Cargotec's design office, and then thirdly, another case study is presented; the MacGregor case study, which shows what kind of differences they have regarding global design operations.

After the results chapter, my own model process is proposed, as well as two tools for achieving successful design office integration. After this, an interaction model for cooperation between global and local design offices is suggested. In addition to the interaction model, some practical suggestions for the future process development efforts at Cargotec are proposed, which should ease offshore design operations in the long-term.

The model and the tools are also tested in practice in a management workshop and in Cargotec's design office in India in order to verify the effectiveness and usability of the tools. The test results are presented in the last section.

The last chapter comprises a discussion and conclusions about the findings in this thesis and answers to the research questions.

2. LITERATURE REVIEW

2.1. Definitions for offshoring design operations and integration

The literature review tries to address the research problem without empirical studies. Interestingly, the topic of the thesis is quite special from the perspective of theory. The integration of design offices combines offshoring and inshoring policies, engineering and project management, cultural awareness issues, global HR, globally distributed engineering and change management. All of these should be combined in order to assess the means, tools and best practices for integrating globally distributed design offices. Unfortunately, there is no single integrating theory.
This chapter starts by looking at types of offshoring and reasons why companies usually transfer their design offices to other countries and especially to low cost countries (LCC). After that, three very different approaches to constructing a theoretical model for integrating design offshoring. are presented After the three models, different areas regarding integration are synthesized and a. model created for the purposes of this particular research Individual models from different areas are brought together to form one coherent model. Lastly, the findings on different risks in offshoring design operations are presented.

First,, it would be appropriate to define the different concepts of offshoring and sourcing. Mishra, Sinha and Thirumalai (2009, p.8) define insourcing, outsourcing and offshoring as follows:

- Collocated insourcing is doing design in one country and in one place.
- Distributed insourcing is distributed design in different cities but in the same country.
- Outsourcing is hiring another firm in the same country to do the design or manufacturing for you.
- Offshoring means that the company has a design office in another country and does the design there.
- Offshore-outsourcing means that a company hires another company to do the design in another country.

Interestingly, the above terminology is not always so clear. For example, IBM and General Electric use the term outsourcing to mean actions that happen in other organizations, but in the same firm. Similarly, some authors differentiate outsourcing to mean only cases where some functions have been at the firm originally, but not anymore. Furthermore, Anderson uses offshoring to mean "whether or not the organizations involved reside within the same firm or different firms" (Anderson et. al., 2007, p. 2-3).

In this thesis, the Mishra, Sinha and Thirumalai (2009) definitions of offshoring are used, for two reasons: first, very strong academic evidence comes from Martin, Massini, and Murtha (2009, p.889), who use the same definitions as Mishra *et .al*. Second, this thesis needs to distinguish between offshoring and offshore-outsourcing because offshore-outsourcing is not dealt with at all.

A closely related term to offshoring design is globally distributed product development. Although the thesis does not deal with global product development *per se*, it shares many things with global design operations. In the most rudimentary sense, global design and global product development share the fact that both consist of people around the world working as a team and *designing* something. Eppinger and Chitkara (2006, p.26) define global product development as being "a single, coordinated product development operation that includes distributed teams in more than one country utilizing a fully digital and connected collaborative product development process."

It is important to recognize that in this thesis when talking about offshoring, *offshoring design operations* are meant. Manufacturing or service offshoring are not dealt with. This emphasis is important, because as Martin, Massini, Murtha (2009, p.889) also remark, the word offshoring as a definition has shifted from perishable goods to immaterial objects, such as design, and from low-wage manufacturing to higher wage white-collar work in low cost countries.

The Merriam-Webster dictionary defines the transitive verb "integrate" as "to form, coordinate, or blend into a functioning or unified whole" (Merriam-Webster, Integrate). When talking about design office integration, the goal is that all different design locations around the world would act as one – as a unified whole. After covering the concepts of offshoring, we can now move to understanding the evolution of offshoring as a process.

2.1.1. Motivation for offshoring

This section will focus on *why* they should do that in the first place. In other words, this section will examine different reasons for companies to offshore. Previous research has found that there are four main motives for companies to offshore design operations.

Labor Cost

Baan & Company's (Vestering, Rouse, Reinert and Varma, 2005, p.3) White Paper about how cost leaders in different areas are moving to low cost countries (LCC) and why they do it, explains that migration is no longer a question of "should we do it", but a must. If one's competitors are going to cut their manufacturing and/or design costs by circa 10%-20%, other companies have to follow them. According to their survey of 138 manufacturing executives from different sectors, they found that 80% had a high priority to move to LCCs. Their own research has found that by moving to LCCs, European and North American companies can cut costs by 20% to 60%.

As an example, Schneider electronics says that its leading reason for setting up international development centers was cutting costs in product expenses (Makumbe, 2008, p. 65).

Focusing only on global product development, the PTC White Paper (2005, p.5-6) identifies two benefits: financial and operational. On the financial side, they claim that the gross savings in global product development are "typically in the range of 0.5% of total revenue and 10% of the product development budget".

Both white papers, PTC's and Baan & Company's, are part of their marketing and should be regarded as such, but they give indications of what the reasons for offshoring are.

Although the white papers talk about cost savings, the literature is not so convinced of the cost cutting motives. Makumbe (2005) conducts a broad literature review on labor cost in offshoring. He reports that researchers such as Eppinger and Chitkara (2006), Doz, Santos and Williamson (2001), Dias and Galina (2000) and von Zedtwitz and Gassman (2000) concluded that companies do offshoring mainly "to reduce product development operating costs…" and "[to] access cheap labor and raw materials". On the other hand, Kumar (2001), Hakanson (1992) and Mansfield et al. (1979) did not find significant proof of cost advantage to multinational companies (MNC). The exceptions are Japanese MNCs, which Kumar (2001) found (See Makumbe 2005, p. 66-67).

In Makumbe's (2005) own statistical analysis based on interviews of different MNC managers, he did not find labor cost to be a statistically significant reason for companies to go in for offshore development. Based on the interviews he conducted, he suspected the reason to be inflation differentials and the competition for skilled employees.

National capability

The PTC's (2005, p.5-6) first operational benefit is faster time-to-market. This is achieved by having engineers working around the world and around the globe. The PTC paper gives an example of doing the most creative and difficult design work in the morning in Europe and then giving the design results in the evening to personnel in, e.g. India and letting them analyze the design. When the Europeans come back to work the next morning, they have their analysis done. A second operational gain would be the improvement on development infrastructure as, in order to be capable of doing shared design work, it needs common tools and databases.

According to Farrel et al. (2005), of all the millions of engineers in India and China, only 13% would be suitable to do high level engineering. Makumbe points out, however, that the research did not say how many US engineers would also be suitable (Makumbe 2005, p. 66-67). This drives competition for good engineers up and raises wage levels. Companies also have to provide interesting assignments for top engineers in order to keep them in-house.

Market potential

The third gain according to the PTC White Paper (2005) is the access to a larger pool of human resources and the understanding of local markets. When a company does design, e.g. in India, they can use their knowledge there, but also the designers understand what requirements and success factors are needed in order to achieve market success.

Makumbe (2008, p.65) reports that the leading companies in complex products such as General Electric, justify the move because of strong market growth in "new" areas and the innovative and highly qualified people in those places. Boeing states that the behind the success of the Boeing 787 was an international development team. From the interviews he also understood that the size of the market was one key location advantage (Makumbe 2008, p.68).

It is also important to recognize that as the world is becoming increasingly global and complex, companies have to be at many locations in order to understand the national markets and especially their diverse customers. Also, the expertise and local knowledge lies in the people of the particular location. Similarly, some countries and locations are hotbeds of some particular know-how. A good example of this would be Silicon Valley in California. It is important to be present in the hotbeds in order to acquire a piece of that knowledge. (McDonough, Kahn, Barczak, 2000)

Global engineering networks

Concerning global engineering networks, Zhang, Gregory and Shi (2007, p. 1273) give three key missions for global engineering networks: effective product development with quality and cost as the key concerns, efficient engineering operations with cost and speed as key factors, and strategic flexibility to be ready for changes and uncertainties. However, "generally speaking, the driving forces for global engineering networks are the increasing complexity and uncertainty of engineering operations". This is because it is important to be able to change one's support markets and business models and access to resources. All of this is based on literature reviews and empirical studies (Zhang, Gregory, Shi, 2007).

Another study on global engineering networks is from Karandikar and Nidamarthi (2006, p. 1043). They argue that the shift of engineering to emerging countries has three main benefits:

1. Fast growing domestic markets. Most emerging countries have a growing local market, so it makes sense to move production there. Also moving engineering to assist production and transfer know-how is a reasonable proposition.
2. Availability of workforce, including highly skilled technical personnel.
3. Low labor costs "… make engineering in emerging countries profitable and a competitive necessity", but "cannot be the sole basis of long-term strategy for distributing the engineering effort". In addition, the authors refer to Stock et al., (2005), Dekkers and van Luttervelt (2006), and Lee and Lau (1999) regarding other advantages, namely flexibility, changeability and agility (see Karandikar and Nidamarthi 2006, p.2).

These three are important when there is a new market opportunity and speed is the main driving factor for taking advantage.

2.1.2. The stages of offshoring

The previous section looked at *why* companies offshore. This section deals with *how* companies can offshore and how to evaluate their position in different levels of offshoring. This is important because many articles recommend that companies have a planned and structured offshoring process (Eppinger and Chitkara 2006, p. 28; Anderson et. al. 2007, p.13). Aron and Singh (2005, p. 141) make a similar recommendation, but it is based on different risk evaluations on operations and structures. There are also a few models on assessing a company's maturity level for offshoring (Zhang, Gregory, Shi, 2007, p.7 and PTC White Paper, 2005, p.4)

2.1.2.1 Offshoring stages

The benefit of doing offshoring in stages comes from a learning curve. When a company does offshoring slowly and in clear phases, the personnel gather knowledge and solve problems bit by bit. Based on a Columbia University study on offshoring companies, it takes time for companies to develop satisfactory offshore development offices. The study found that companies that have been outsourcing less than a year are not satisfied but those which have more experience of outsourcing are (see Eppinger and Chitkara, 2006, p.28). At the same time, the relationship and trust between locations builds up. Trust is required in order to develop higher level co-operation (Jarvenpaa and Leidner, 1999, p.2).

Eppinger and Chitkara's (2006, p.28) stage model has three levels, with every level divided into stages (see Figure 1). The levels are (from first to third): Process Outsourcing, Component Outsourcing and Captive Design Center. Although they talk about outsourcing, they also mean offshoring in captive centers.

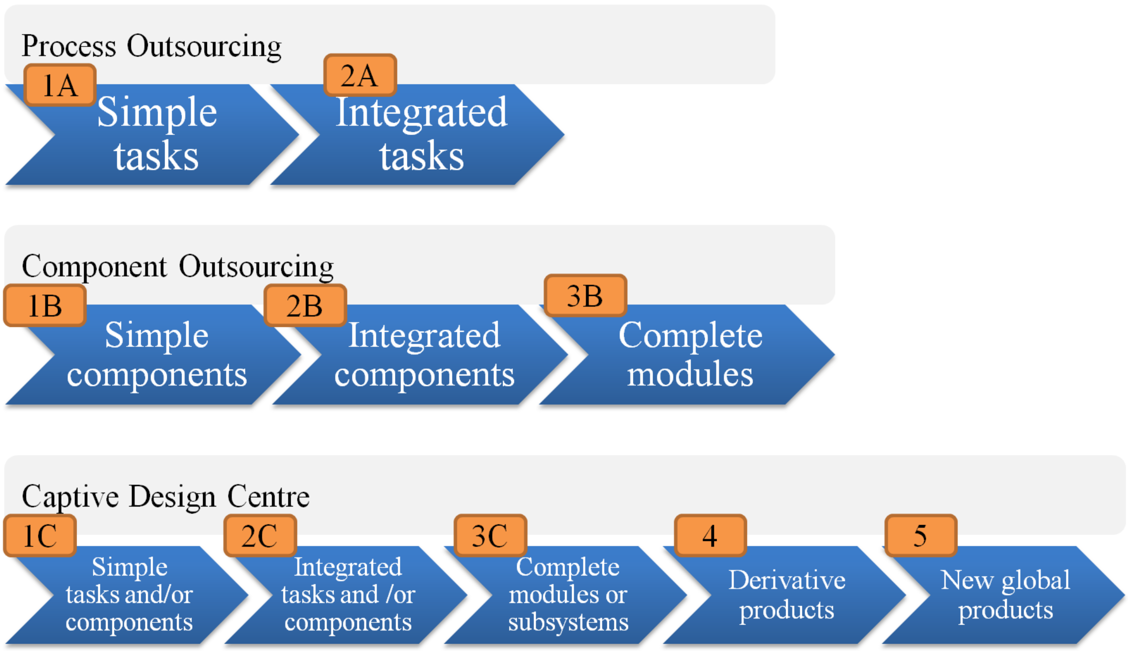

Figure 1 Eppinger and Chitkara's (2006, p.28) outsourcing stages

At the Process Outsourcing level companies only outsource tasks. At stage one of the Process Outsourcing level companies outsource simple tasks that are easily divisible to outside partners. At the second stage, they move to more complex tasks, such as tooling design. At the second level, component outsourcing, the companies outsource not only tasks but also component and module design operations. At the first stage, companies outsource simple components. At the second stage, companies outsource integrated components with tasks involved in them. Finally, at stage three, they can outsource complete modules, such as the exhaust system of a vehicle. At the third level, Captive Design Centers, outsourcing becomes a strategic choice. The first three stages of the third level are similar to those of the second level, except that at stage three there are also subsystems involved. The authors give an example of a control system for an electromechanical system. The fourth stage is a very integrated extension, where the main office takes complete responsibility for, e.g. engineering support for an existing product. From stage four on the real strategic benefit kicks in. At the fifth stage, the offshored/outsourced office has complete responsibility for new product development and platforms. Companies should use all three levels as different approaches and balance them between the needs and strategy of the company. Although companies can use the levels at the same time, Eppinger and Chitkara (2006, p.28) argue that it takes at least a year for companies to advance to the next level.

2.1.2.2 Maturity levels

It is important to understand where an organization is at the moment, before it can plan the road to offshoring. The maturity levels are very similar to the offshoring stages, with the difference that the maturity levels are more concerned with identifying companies' status and the stages are closer to process models.

The PTC paper categorizes organizations into five different maturity levels: Level 1 - None, Level 2 - ad Hoc, Level 3 - Discrete, Level 4 Co-Development and finally level 5 - Transformational Outsourcing. At level 1, a company does not have any meaningful product development operations outside their own country. The writers of this paper claim that many Western companies are at this level. At level 2, companies have operations, mainly through mergers or acquisitions. The problem is that most companies did not plan to have these operations and do not have a strategy for them. Thus, they do not know how to balance cost and value-adding at their offshore locations. At level 3, companies offshore different design and development operations, which lack importance for their core competencies or key areas. For instance, they could offshore technical publications and even simulations. At level 4, sharing design responsibilities has deepened from level 3. Now, even entire subassemblies are given to offshore locations or special projects, such as improvements in reliability. The PTC paper says that "most companies in high-cost regions envision getting to level 4 over a period of time". At level 5, the main office only gets customer requirements and distributes these to different locations around the world. At level 5, the company is only an interface for the customer to produce what the customer needs and wants. Not all companies want to achieve level 5 for fear of losing the capability of product development (PTC White Paper, 2005, p.4-5).

Zhang, Gregory, Shi, (2007, p. 1275) have a very similar maturity model to that of the PTC White Paper (see Figure 2). The main differences are the choice of words, tone and lack of the PTC's level 1. In addition, they use a matrix table which has the stages going horizontally and different affected areas vertically. The areas are: communication and sharing, integration and synergizing, innovation and learning and adaptation and restructuring.

	Level I	Level II	Level III	Level IV
Communication and sharing: accessing and linking dispersed engineering resources	Isolated resources	Separating when projects complete	Exchanging resources regularly	Interdependent centres
Integration and synergizing: coordinating engineering operations for global efficiency	Standalone centres	Initiatives of global project	Regional or divisional coordination	International operations synergies
Innovation and learning: capturing and transferring internal and external knowledge	Re-inventing the wheel	Modularized solutions	Institutional learning	Innovation as a culture
Adaptation and restructuring: reconfiguring engineering resource for changes	Arbitrary decisions of key individuals	Established processes, but for reference	Effective processes across company	Self-optimizing

Figure 2 Matrix table of maturity model for offshoring (Zhang, Gregory, Shi, 2007, p.1275)

This section looked at the definitions and different maturity and stage models for companies to understand where they are regarding to different levels of offshoring. In the next sections I will examine exactly how companies can transform their local design operations to global.

2.2. Models for integration and transfer

In this section I will try to give an overall picture of the literature about what is needed in order for companies to achieve offshore design office integration. From all the literature reviewed, only one article had a model for starting a partnership with an offshore partner (Karandikar and Nidamarthi, 2006). Fortunately, there are other options. After Karandikar and Nidamarthi’s article I present a model from virtual team literature because, after all, global design is virtual team work. The third model is the author´s own collection of success factors in supplier integration.

2.2.1. Model for transition to globalized development

Karandikar and Nidamarthi’s (2006, p.1044) article discusses the special case of transferring offshoring design from an industrialized country to an emerging one. Because their model is the only one currently available, I will give a detailed description of it and its results will be given. Their arguments will be supported or refuted with other articles.

With the focus on industrialized countries come two special challenges: intellectual property problems and the fear of losing skill from these countries. About these problems, Karandikar and Nidamarthi’s (2006, p.1045) state that “While there is little grounding, in fact there is a strong perception among engineers in the industrialized countries that their counterparts in the emerging countries will easily defect, along with the know-how, to competition in the emerging countries markets”. This statement is in direct opposition to the remarks about Polish workers in Passport Poland (Natalia Kissel, Serge Koperdak, 2001, p.39), and Hart (2010, p.6). However, I could not find any statistical hard evidence against the claim in the low-cost country context.

The problem of industrialized country designers leaving the company is caused by them seeing work flow to the emerging countries and seeing that as a threat to their medium to long-term job prospects. This can result in a loss of critical skill. Although the reasons to offshore are presented above (in Section 2.1.2), Karandikar and Nidamarthi (2006, p.1054) emphasize the importance of not doing offshoring only because of cost savings: “One common aspect critical to the success was the fact that in all cases cost reduction was not made the sole and primary driver to set up the GEN [Global Engineering Network]. It was seen as a result or an added benefit.”

Their model was conceived through three cases, which lasted three years. Case 1, regarding automated manufacturing system delivery, gave them the basis of the model. Case 2, regarding a power automation developer, revised the original model and they added two elements to it. Case 3, regarding a build-to-order electrical equipment company, confirmed their findings. Post-mortem analysis gave them “confidence in the relevance and applicability of this model” (Karandikar and Nidamarthi (2006, p.1047).

Karandikar and Nidamarthi's (2006, p.1055) model is based essentially on three areas: change management, team building and competence building. In the model, there are three foundational elements and three transformational processes. See Figure 3 below.

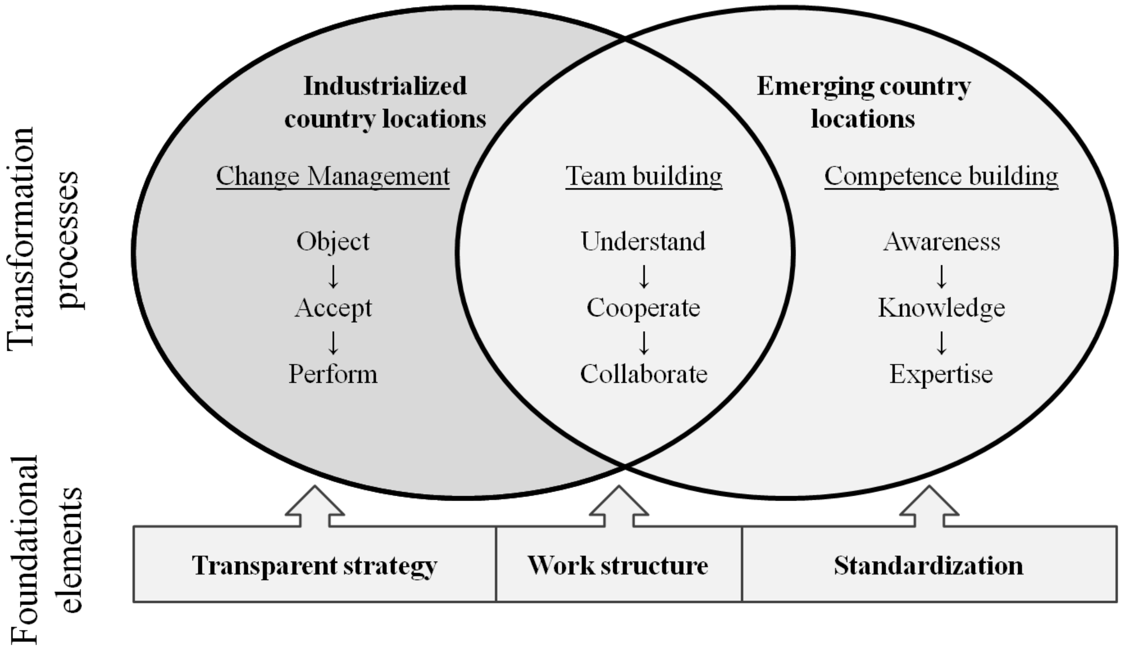

Figure 3 Karandikar and Nidamarthi's model for a successful transition to globalized development (2006, p. 1046)

Foundational elements

Foundational elements are crucial to forming a strong baseline to guide the transformation process from locally managed design operations to global and distributed ones. A similar method has been used by, e.g. Ragatz, Handfield and Scannell (1997, p.200)

In setting up a Transparent Strategy it is important for executives to understand *and* communicate the reasons behind the shift to global development. The reasons are covered in detail in Section 2.1.1. Work structures consist of mapping *and* communicating the new development organization, how the work is distributed across locations and what are the responsibilities. There have to be clear-cut rules about what belongs to industrialized country and emerging country locations. This is needed to "counter unfounded fears and to rationally deal with well-founded concerns" (supported by PTC's, 2005, p.12). The last foundational element is to define and standardize engineering content as far as it is useful. Engineering content does not mean only parts and components, but also engineering solutions, concepts and design rules (Karandikar and Nidamarthi,2006, p.1048). This can be partly done, for instance, by Ward's (2007, p.137) trade off curves, which are found to be extremely efficient in transferring design knowledge. Karandikar and Nidamarthi (2006, p.1048) also suggest sales and supply departments should standardize their operations in order to have the same rules for the whole global operation. Many other authors recommend standardization of design work into an easy global design. In Section 2.3.1., wide support for this is presented.

Transformational processes

Transformational processes are closer to everyday work than the foundational elements. Transformational processes should be run in parallel, but individually tailored, to every location, i.e. emerging country and industrialized country locations have their own. The first transformational process, change management, is connected strongly to the first two foundational elements, transparent strategy and work structure. Because it is not easy or automatic for engineers to change their design practices, they need comprehensive support and guidance to get there. That is why, especially in industrialized country locations, change management has to be well thought out and thorough. In industrialized countries, the authors, Karandikar and Nidamarthi (2006, p.1049), emphasize using change "champions" who are excited about the change. In addition, in Karandikar and Nidamarthi's experience, the change should be communicated as an opportunity for "innovation and cost-competitive entry to new markets…"(Karandikar and Nidamarthi, 2006, p.1048). Change champions and involvement in the change process have been proposed for decades to assist the change process (Sirkin, Keenan and Jackson, 2005, p.4; Kotter and Schlesinger, 1979, p. 109-110). On the other hand, a healthy amount of resistance and conflict often brings better results (Waddell and Sohal, 1998, p.547).

The second transformational process, team building, is common to both industrialized countries and emerging countries (also Govindarajan and Gupta, 2001). The goal is to have a consistent, defined plan to bridge the new and old ways of doing engineering together. Trust is a critical factor in the long-term and the assumption of collaboration (also Jarvenpaa and Leidner, 1999, p.806-809). This brings about a unified team spirit, which allows the global network to carry and deliver the promises of a global engineering effort. (Karandikar and Nidamarthi, 2006, p.1049) Ragatz, Handfield and Scannell (1997, p. 197) found, according to their respondents, that trust in outside suppliers develops a more through performance according to expectations over time than from formal or managed trust building exercises.

The third transformational process is competence building (strong additional evidence from Sole and Edmondso, 2002, p.30-31). The meaning of competence building is to share knowledge and slowly give the emerging country more complex and difficult tasks. In practice, the sharing of knowledge is done by rotating skilled technical personnel in *both directions* and through access to standardized engineering know-how. This can include, for example, documented standard designs. Karandikar and Nidamarthi (2006, p.8) emphasize that engineering is not only technical competence but also understanding typical customer problems and the skill of converting customer requirements and needs into "workable and manufacturable designs" (Karandikar and Nidamarthi, 2006, p.1049).

Revised article

Karandikar and Nidamarthi (2006, p.1049-1054) based and tested the model in three case studies over three years and found it to be workable. Karandikar (2009) updated this article for a book by Springer, “Dispersed Manufacturing Networks: Challenges for Research and Practice”. When Karandikar (2009) mentions the lack of literature about the process of transition from localized to globalized development, he mentions only the Karandikar and Nidamarthi (2006) article. So, it appears that at present there is still no more literature about the transition process.

In the updated Karandikar (2009) article there is one added case study from 2007 and one interesting note about communication in global engineering networks. He argues that despite the model they created in 2006; the communication needs to be in a closed loop (see Figure 4).

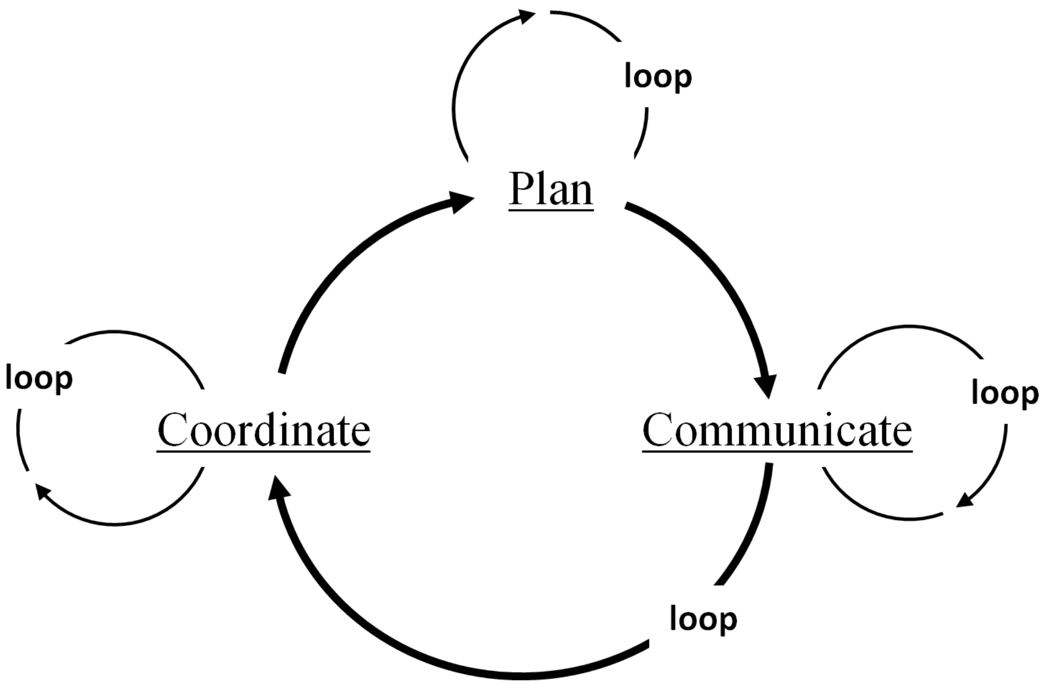

Figure 4 The closed loop of global engineering networks communication (Karandikar, 2009, p.231)

The idea of the closed loop is that the bigger plan-communicate-coordinate communication loop between different departments and locations needs the smaller loops to verify and fully understand each other. This is a better way to communicate than “broadcasting” information, or even “knowledge”, by e-mail to many shareholders. Broadcasting does not mean that the message is really understood or even received. This is why the smaller loops are essential. The loops should be applied to formal and informal communication (Karandikar, 2009, p.231 and supported by Argyris, 1977, p.122).

Case studies

Although the Karandikar and Nidamarthi (2006) model has been extracted from three cases, their individual foundational elements and transformation processes are different from each other and more specialized than the model. They are presented as “model strategies”, which carried the companies to successful offshoring. Another case was added by Karandikar (2009).

Karandikar and Nidamarthi (2006, p.13) summarize their cases findings as follows:

- well-communicated and transparent strategy in cases 2 and 3;
- well-defined work structure in cases 2 and 3;
- engineering standardization, designs as well as work processes, in cases 1 and 3;
- importance of implementing a change management process in cases 1 and 2;
- well-thought out team building in cases 1 and 2; and
- well-planned competence building in cases 1 and 3."

Karandikar (2009, p. 238) states at the end of his article that all four cases have successfully established industrialized country and emerging country relations. However, he also remarks that because of the lack of further literature and research there has to be additional research done on the topic.

Problems of the model

As one can see, the individual points made by Karandikar and Nidamarthi (2006) have been supported by other research and articles. Here, I will present the problems perceived by myself with the *whole* model and its assumptions.

One obvious problem, which the authors also point out, is the lack of test data from the model. Their data and model were based on three cases, but completely lacked broad statistical analysis from a broader sample. My main problem with the model is its generality. The model is based on the three cases but the cases are quite varied in technical challenges, the type of design and the generality of the model. Of course, this study being the first of its kind, perhaps that was the point of the authors. On the other hand, for practitioners the study gives only clues as to where to start and structure the transition process. A more detailed description of how the three companies *actually* managed and handled the transition as a process could arguably have been included.

Another problem is that all three cases are from different engineering disciplines: development of manufacturing machines, software heavy power automation and electrical equipment. Case company 1 sold only "tens of products per year and Case company 3 made only engineered-to-order products. It has to be said, though, that although they are from different fields of engineering, it does not *necessarily* have to invalidate the transition into a distributed design process. The authors merely do not mention this problem at all.

2.2.2. Model from virtual team literature

In this section, the literature of virtual teams (VTs) is discussed as a second model for global design operations. The aim here is not to produce a similar transformation model as in the last section, as that is not possible from the virtual team literature; however, models on how virtual teams can be made to work efficiently are presented.

For this section, a literature review article about virtual teams by Powell, Piccoli and Ives (2004) has been used as a basis. Their article is only referred to as a second hand

reference when they have comprised a conclusion from three or more references, in order to be sure about their validity.
One can ask, whether the research on VTs is applicable to global engineering and its problems. Let us look at the definition that two authors of virtual team literature review papers have selected for VTs:
"We define virtual teams as groups of geographically, organizationally and/or time dispersed workers brought together by information and telecommunication technologies to accomplish one or more organizational tasks." (Powell, Piccoli and Ives, 2004, p.7)
Another article defines virtual teams as "small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks." (Ebrahim, Ahmed and Taha, 2009, p.2655)
Ebrahim, Ahmed and Taha (2009, p. 2654) state that Powell, Piccoli and Ives' (2004) article is the most widely accepted. I would interpret both of the definitions to be inclusive of global engineering.
Both articles state that research on virtual teams is in its infancy. Despite this, Powell, Piccoli and Ives (2004, p.8) found and investigated 43 articles about VTs. From those they compiled a diagram which shows the current focus and relations of VT research (see Figure 5).

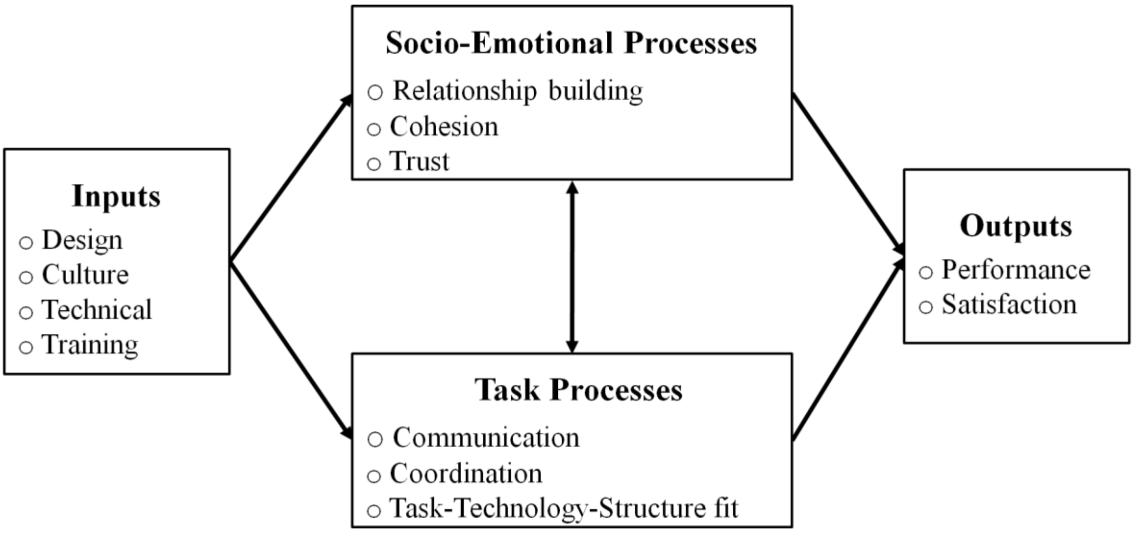

Figure 5 Diagram of the focus of virtual team research (Powell, Piccoli and Ives, 2004, p.8)

The following sections are divided according to the diagram.

2.2.2.1 Inputs

This section is closest to the topic of the thesis. It deals with the resources, skills and abilities, which are required to get the team working.

Design of a virtual team means simply that forming a VT should be planned. This means structuring the interactions; what kind of communication tools are used, how much face-to-face time will be possible, etc. Research has found that team building exercises (Kaiser et al., 2000, p.80), the establishment of shared norms (Sarker et al., 2001, p.50) and the establishment of a clear team structure (Kaiser et al., 2000, p.81) helps the team to succeed (Powell, Piccoli and Ives, 2004, p.8). Kirkman et. al (2004, p.186) found empirically that having more face-to-face meetings improved the empowerment of virtual teams, which leads to better learning. Numerous communication problems can be diverted by creating shared knowledge databases in order to allow all the team members to have the same information and to know that others have it, too (Crampton, 2001, p.355-359). As an added bonus, shared knowledge databases also share the same language and mental models, which are substitutes for the all important face-to-face time. Furthermore, shared mental models can be focused through designing, requiring the teams to create goals and strategies. This has been shown clearly to improve the teams (Suchan and Hayzak, 2001, p.185).

With **cultural differences** also coordination problems and obstacles to effective communication can be involved (see Powell, Piccoli and Ives, 2004, p.9). These problems may be solved by actively understanding and accepting differences in cultures (Robey, Khoo and Powers, (2000), p.58).

The **technical expertise** of a team seems to have a positive effect on the team's performance and the satisfaction of belonging to the team (Van Ryssen and Godar, 2000, p. 55-56). At the same time, high trust is found to develop (Jarvenpaa and Leidner 1999, 807). On the other hand, ”the relationship between technology and task performance is found to be more dependent on experience with technology and with group membership than the type of task on which the group was working” (Hollingshead, McGrath and O'Connor, 1993, p.328).

Diverse technological skills can create conflict among the team (Sarker and Sahay 2002, p.4-5). This is why teams should have consistent **training** to improve team performance (Kaiser et al., 2000, p.80). For instance, mentoring is a good way to make personal ties to more experienced virtual team professionals (Suchan and Hayzak, 2001, p.183). According to Tan et al. (2000, p.160), consistent training fosters cohesiveness, trust, team work, commitment to team goals, individual satisfaction and higher perceived decision quality. In their article, they taught a communication technique called the dialogue technique. It is created through three stages: small talk, sharing mental models and norm building.

2.2.2.2 Socio-emotional processes

This section introduces the emotional problems involved and mitigation tactics needed to achieve cohesion and trust among team members. Overall, the research about this reports “a positive link between socio-emotional process and outcomes of the virtual team project.” (Powell, Piccoli and Ives, 2004, p.9-10)

Because of geographical distribution, face-to-face time occurs only rarely. This, according to research, results in weaker social links between team-mates and leads the team to be more task-focused than socially focused (see Powell, Piccoli and Ives, 2004, p.10). If face-to-face meetings are feasible, meetings should be held as much as possible at the beginning of the team formation in order to bring team-mates closer and form interpersonal bonds. These meetings should focus more on **relationship building** than on actual business (Robey, Khoo and Powers 2000, p.59). However, with socializing different cultural preferences have to be remembered (Powell, Piccoli and Ives, 2004, p.10).

If face-to-face meetings are not possible or feasible to the desired extent, other approaches can be applied. Social-bonding can be done partially via electronic communication tools. Jarvenpaa and Leidner's (1999, p.807) study found that if teams communicate more socially they achieve higher trust and better social and emotional relationships. Leaders can help foster relationship building and general team building in many ways, e.g. by providing continuous feedback, listening to team members' opinions and suggestions, clearly stating the team member roles and having consistency in their leadership style (Kayworth and Leidner, 2001, p.25).

Cohesion means the sense of unity in a team. It is found to be important, but there are no conclusive results on how to support it in the virtual team context (Powell, Piccoli and Ives, 2004, p.10).

Trust is particularly problematic subject with virtual teams, because it is arguable whether people can be expected to trust each other if they have never met face–to-face (McDonough, Kahn, Barczak, 2000, p.115-116). Furthermore, trust is noted to be crucial in successful teams, but usually there is not much time to build it little by little because often the teams are short-lived in projects. Jarvenpaa and Leidner (1999, p.794) describe a mechanism of how people solve the trust problem in a short time. It is called the swift trust paradigm and it suggests that team members assume from the beginning that the other team members are trustworthy. They adjust that assumption during the lifetime of the team. Jarvenpaa and Leidner (1999, p.794) also researched the differences between teams that had a high level of trust in the beginning and teams with a high amount of trust in the end and compared them. To achieve high trust early in the group's life, the team had social and enthusiastic communication and they coped well with technical uncertainty and took individual initiatives. The groups that enjoyed trust later had predictable communication, timely responses, positive leadership and the ability to move from social communication to task-focused communication (Jarvenpaa and Leidner, 1999, p.807).

2.2.2.3 Task processes

Task processes are the different functions that happen when a team is doing its work.

Communication is one of the most crucial things in virtual teams. It starts from selecting excellent communicators for the team members and the right technology for them to use. (Powell, Piccoli and Ives, 2004, p.11) Some empirically found challenges in successful communication in virtual teams are failure to communicate due to wrong or lacking contextual information, unevenly distributed information, interpretation of the meaning of silence and technical problems (Crampton, 2001, p.360). Because of the lack of face-to-face time, the team can miss nonverbal communication altogether. The extensive reliance on communication technology leads to reduced impact and difficulties in management compared to the traditional teams (McDonough, Kahn, Barczak, 2000, p.119). Researchers have found some solutions for these problems. One company has created a reward system for team cooperation to encourage people to actively and accurately communicate (Suchan and Hayzak, 2001, p.179). On the other hand, according to Pink's (2009) research on rewarding creativity, rewarding communication is not a sustainable way to encourage cooperation. In another company, they emphasized the need to debate as well as merely share information (Kruempel, 2000, p. 191). Predictability and feedback also frequently improve communication effectiveness, creating trust and better team performance (Powell, Piccoli and Ives, 2004, p.11).

In addition, in one study researchers tested the question of whether adding video to electronic communication helps to explain a detailed task (a map route) to another person (Veinott, Olson, Olson and Fu, 1999, p. 303). They found that for native speaker pairs it did not bring any additional benefits, but for non-native speaker pairs it brought significant improvement to the task (Veinott, Olson, Olson and Fu, 1999, p. 307).

It is, naturally, more difficult to **coordinate** virtual teams in different time zones, cultures and mental models. Collaboration norms have to develop for the team to function well (Powell, Piccoli and Ives, 2004, p.12). As mentioned before, periodical face-to-face meetings are a good way to form relationships and also a good vehicle to coordinate activities and to drive the project forward (Maznevski and Chudoba, 2000, p.489). When face-to-face meetings are not feasible, one alternative is to develop coordination protocols with communication training (Powell, Piccoli and Ives, 2004, p.11-12). Ramesh and Dennis (2002, p.7) have suggested standardizing the team's inputs, processes and/or outputs. This should help the team to coordinate and help the other party.

The **task-technology-structure** fit examines "the possible fit between various technologies available..." (Powell, Piccoli and Ives, 2004, p.12). Studies have hypothesized that the technology fit depends on individual preferences, e.g. experience of use and the urgency of the task (Hollingshead et al., 1993; Maznevski and Chudoba, 2000, p.489; Robey, Khoo and Powers, 2000, p.59). Majchrzak et al. (2000, p.580-590) found that face-to-face meetings or phones calls are suitable for ambiguous tasks, managing conflicts, managing external resources, brainstorming and strategic talks. Electric communication is more suitable for more structured tasks such as routine analysis, examining design tradeoffs and monitoring project status. Interestingly, in their study the team first adjusted their organization to the technology at hand, but later also adjusted the technology to their organization.

2.2.2.4 Outputs

Output in virtual teams means all the things that come out of the work processes of the team.

When comparing **the performance of** traditional and virtual teams, the results are mixed. Some studies find traditional teams and some virtual teams to be better. The majority of studies have found the teams to be about at the same level (Powell, Piccoli and Ives, 2004, p.12-13). Powell, Piccoli and Ives (2004, p.13) list many studies that have found different factors, which make virtual teams successful. The factors are:

- Training
- Strategy/goal setting
- Developing shared language
- Team building
- Team cohesiveness
- Communication
- Coordination and commitment of the team
- The appropriate task-technology fit
- Competitive and collaborative conflict behaviors (conversely, the same study found that avoidance and compromise conflict behavior had a negative impact)

The results from different student studies are mixed concerning working in a virtual team (Powell, Piccoli and Ives, 2004, p.13). Tan et al. (2000) found that teams which used their dialogue technique were more **satisfied** with decisions made in the team. It is difficult to agree with Powell, Piccoli and Ives' (2004, p.13) generalization, according to which, referring to Tan et al. (2000), training will increase satisfaction in teams. Tan et al.(2000) discussed only about how decision satisfaction rises when dialogue technique is applied. Interestingly, one study found that a traditional team started out more satisfied than a virtual team. Then, in less than a year, the satisfaction of the virtual team rose and exceeded the satisfaction of the traditional team (Eveland and Bikson, 1988, p.368). Furthermore, some studies have found that women, generally, are happier in virtual teams than men (Lind, 1999, p.280).

2.2.2.5 Problems of the virtual-team model

Although the virtual team model is very interesting in many aspects, it has some general problems. The most fundamental problem is its background. The background problem is that the model is essentially a collection of topics that the virtual team researchers have researched for the last decade or so. This means that it should not be regarded as a guiding model, *per se*, but a collection of ideas and practices that have been studied.

Another problem is its applicability for design operations. Although design operations in globally distributed teams are very similar to virtual teams, design virtual teams have their own unique issues that should be taken into consideration when extracting conclusions from the virtual team model. For instance, the technical expertise and task-technology-fit are more important in the design context than, say, in accounting.
As Powell, Piccoli and Ives (2004, p.14) mention, a big problem with current virtual team research is the team size. 90% of studies are done with less than eight individuals in the team. When companies are offshoring more and more design people, the virtual team sizes are growing. What kinds of problems do virtual design teams face when there are over ten designers? What happens when the team includes over 20 people?
One very interesting research question would be, which elements of the model have more impact than others. At the moment, all the elements (design, culture, etc.) are assumed to have the same impact on the success of virtual teams. I would assume that the impacts of various elements are different when studying different professional areas and geographical areas.

2.2.3. Success factors for integrating suppliers into new product development

In this third and last section of different models from the literature for successful integration, literature findings from 20 articles will be presented concerning factors which lead to supplier integration success in new product development. With integration I mean all the things that improve the "oneness" of the supply chain (Bagchi et al., 2005, p.276). The reason why integration is wanted in the first place is because "the normative implicit assumption is that integration is the best way to obtain efficiency of the supply chain" (Bagchi et al., 2005, p.277). The point of this section is to study the success factors which improve the relationship between the supplier and the buyer in a new product development context, in addition to all the things that improve the oneness of the supply chain. The goal of this research is to find some coherent factors that drive good integration (see Table 1). The suppliers' connections to *new product development efforts* will be focused on, but not everything that supplier integration stands for.

Table 1 A summary of findings from the success factors in supplier integration in new product development.

Topic	Found Success Factors	Authors (See appendix 5 for the full references)
Long-term relationship	Long-term commitment to suppliers; offering long-term contracts , jointly setting up business strategies, aligning supplier's business direction to company mission, involving supplier in planning process; formal risk/reward sharing agreements , strategic orientation; sharing of technology information; supplier involvement ; sequentially adding supplier quality control, technical difficulty and interaction between those, ensuring that the supplier is "accepted" among the development team; effective alignment of buying and supplying organizations; commitment; motivating suppliers to develop specific knowledge or products;	1; 5; 6; 9; 11; 12; 15; 16;
Trust	Mutual respect/trust; trust and common ground; mutual trust, ; the sharing of technological and customer requirements information; fostering and nurturing a sense of trust; trust; socialization: coordination through a social relations network based on norms of trust and reciprocity	3; 4; 5; 6; 7; 14; 15; 20
Open and seamless cooperation	Joint responsibility for design and configuration control; team empowerment, overarching team goals, creative problem-solving; Inclusiveness, 5transparency, asymmetric giving as trigger and reciprocity, shared relational responsibility; jointly solving quality problem, mutually sharing knowledge in quality improvement ; shared education, training, sharing of personnel and facilities; information sharing; information sharing and involvement to the NPD process; involvement of the supplier to the NPD; technology sharing, and supplier participation on the project team; cross-department innovation meetings with suppliers; mutual support; motivating suppliers to build up/maintain specific knowledge or develop certain products, exploiting the technical capabilities of suppliers, suggesting alternative suppliers/products/technologies, evaluating product designs, promoting standardisation and simplification;	1; 3; 4; 5; 6; 7; 9; 10; 12; 13; 14; 18;
Open communication	Socialization mechanics (e.g. team-building exercises, social events, joint workshops and supplier conferences); frequent, genuine communication, Sharing and use of uncertain information, flexibility and openness to learning/willingness to change; openness of communication ; inter-company communication,; bilateral communication; openness, communication,; designing communication interface with suppliers; Providing information about the products; open sharing of information, adequate (not maximum) level frequency and intensity of communication; coordination through informal communication, often among peers and including the use of teams	2; 3; 5; 6; 7; 14; 16; 18; 19; 20

Topic	(continues from the last page) **Found Success Factors**	**Authors** (See appendix 5 for the full references)
Mapping the supplier beforehand	Strategic alignment between functions; careful analysis of prospective suppliers,; formal supplier assessment and selection process; Analysis of potential supplier: mapping the capabilities and culture; mapping the suppliers processes and products; competence of the supplier (technology and innovative out-side point-of-view), "fit" of the team members and competence of the team members; supplier-specific adaptations; determining in/outsourcing technologies and NPD activities, pre-selecting supplier for future involvement in NPD, exploiting existing supplier skills and capabilities, monitoring supplier markets and current suppliers for relevant developments; pre-selecting suppliers for product development collaboration, selecting suppliers for development projects; technical expertise and experience and social and project management skills, evaluation of supplier not only technical/price settings but also future components and collaborative fit (collaboration level on past projects);	3; 6; 7; 10; 14; 15; 16; 18; 19;
Coordination of the supplier	Boundary management; coordination and control of the suppliers ; formal purchasing commodity strategy development process; coordination and planning, company alignment with the supply chain; formulating and communicating guidelines/procedures for supplier involvement, periodically evaluating guidelines and supplier base performance, coordinating development activities with suppliers; determining the scope of integration, formulating policies for supplier involvement in R&D but also in other departments, communicating these policies, determining the extent and moment of their involvement, coordinating their actions; supervision - coordination through an individual who is a common superior, standardization: coordination through the use of rules and procedures;	3; 6; 7; 8; 16; 18; 20
Performance measures	Target costing, incentive mechanisms that make cooperative behaviour possible; innovation performance measures; team-based accountability, team-based rewards and recognition; confidence in supplier quality; joint agreement on performance measures; evaluating/feeding back supplier performance; monitoring supplier markets for technical developments, evaluating suppliers' development and performance;	1; 2; 3; 5; 6; 16; 18;
Special aspects	Modularity; visible innovation culture with suppliers; using relationship representatives	8; 13; 15;

From the above summary chart about the findings in success factors in supplier integration, the diagram below helps to understand them in relation to each other.

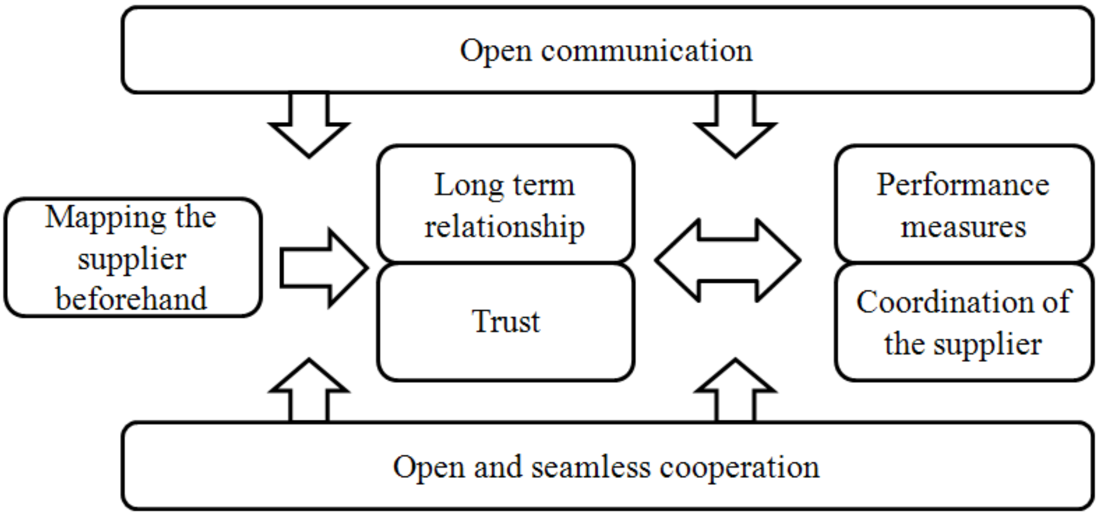

Figure 6 Success factors in supplier integration into new product development

The above diagram depicts the found success factors in a framework. The framework suggests that buyers should first map, evaluate and test the supplier rigorously. In forming long-term relationships, the buyer invests in the relationship and deep trust can form naturally. Though companies form long-term relationships and trust, the buyer should measure the supplier's performance and development. In addition, the suppliers need guidance and sometimes a firm hand to help them make the right decisions or investments. All this should be compiled to form a truly open atmosphere of communication practices, even allowing debates, and seamless cooperation where the buyer and the supplier share information and practices. Next, I will go deeper into every section and present the thesis findings in more concrete terms. However, as this section is not the focal point of the thesis, they will be presented in brief.

2.2.3.1 Success factor framework

Mapping the supplier beforehand

The literature generally recommends analysing prospective suppliers (e.g. McGinnis and Vallopra, 1999, p.14; Monczka, Petersen and Handfield, 1998, p.568-569; Petersen, Handfield and Ragatz, 2005, p.384). Handfield and Ragatz (2005, p.384) recommend inspecting not only the performance, but also the company culture of the supplier. In the same spirit, Hoegl and Wagner (2006, p.542-543) suggest evaluating technical expertise *and* the social and project management skills. Because the relationship of the buyer and the supplier should be a long-term one (as argued below), it is important to evaluate and understand the supplier's future capabilities and the collaborative fit (Hoegl and Wagner, 2006, p.542-543).

Long-term relationship

Long-term commitment to the supplier (and to the buyer from the other perspective) is seen as beneficial for every party (e.g. Bozdogan et al., 1998, p.171; Lo and Yeung, 2006, p.213). When both parties understand from the beginning that the relationship will continue for years, they can develop confidence in the development and sharing of technologies and knowledge (e.g. Lo and Yeung, 2006, p.213; van Echteltn, Wynstra and van Weele, 2008, p.196; Petersen, Handfield and Ragatz, 2005, p.293-295). Long-term relationships also give a logical growth foundation and motivation (van Echteltn, Wynstra and van Weele, 2008, p.196) for the supplier to gradually take more technically complex jobs when both parties gain experience of working with each other (Primo and Amundson, 2002, p.46).

Trust

Many authors emphasize the role of trust in buyer-supplier relationships (Holland, Gaston and Gomes, 2000, p.239; Lambrechts, Taillieu and Koen, 2010, p.98; Lo and Yeung, 2006, p.213; Wagner and Hoegl, 2006, p.940-941). Trust will not develop automatically. It needs a good foundation. A long lasting relationship is the first step toward it. Other ways to obtain trust are found in Gerwin's article (2004, p.248). He suggests that through socialization (team building exercises, social events, joint workshops and supplier conferences [Cousins and Lawson, 2007, p.312]), developing and coordination of social networks trust can be gained with time.

Performance measures

Many authors have found performance measures to be effective in getting the best from suppliers (Holland, Gaston and Gomes, 2000, p.239; McGinnis and Vallopra, 1999, p.14; Wynstra, van Weele and Weggemann, 2001, p.161). However, it has to be stated that some have also found problems in them. Bozdogan et al. (1998, p.171) suggest incentive mechanics that make cooperation possible, but also state that incentives can work against the buyer if they are not put into place skillfully. Also, McGinnis and Vallopra (1999, p.14) recommend that all measures be done together with the supplier. Other authors recommend having performance measures for innovation activities in order to encourage the supplier to start innovations (Cousins and Lawson, 2007, p.312; Wynstra, van Weele and Weggemann, 2001, p.161).

Coordination of the supplier

A partly self-evident success factor is the coordination of the supplier (McGinnis and Vallopra, 1999, p.14; Pero et al., 2010, p.123; Wynstra, van Weele and Weggemann, 2001, p.161). The buyer should coordinate the suppliers' actions in some way. Holland, Gaston and Gomes (2000, p.239) suggest setting boundaries for suppliers so that they have freedom to move inside the boundaries. The boundaries can be revised when needed. Another way is to align the supplier to the buyer’s operations so that the alignment itself will coordinate and guide the supplier (Monczka, Petersen and Handfield, 1998, pp.568-569; van Echteltn, Wynstra and van Weele, 2008, p.196). The buyer can also make different policies that the supplier will uphold (Wynstra, van Weele and Weggemann, 2001, p.161). In the product development context, it is especially important to create a strategy or guidelines, as to when the supplier will be involved in the product development process and operations (Wynstra, van Weele and Weggemann, 2001, p.161). To aid the product development effort, the standardization of some aspects of it improves the quality of the cooperation (Gerwin, 2004, p.248). An interesting suggestion is also that the buyer may appoint a supervisor (Gerwin, 2004, p.248) or “relationship representatives” (Walter, 2003, p.727) to assist the cooperation.

Open and seamless cooperation

A key success factor is the cooperation of the supplier and the buyer. Cooperation means sharing and involvement. It means sharing relational responsibility and reciprocity (Lambrechts, Taillieu and Koen, 2010, p.98), sharing education and training (McGinnis and Vallopra, 1999, p.14), sharing of information (Monczka, Petersen and Handfield, 1998 p.568-569; Petersen, Handfield and Ragatz, 2005, p.384) and sharing of technology (Handfield and Ragatz, 2005, p.384). On the other hand, it also means involvement. Suppliers should be encouraged and supported to involve themselves in the development of new products (Petersen, Handfield and Ragatz, 2005, p.293-295), in innovation (Schiele, 2010, p.145) and in the evaluation and suggestions for of new technologies and solutions (Wynstra, van Weele and Weggemann, 2001, p.161). Healthy and mutual cooperation should result in joint responsibility for design (Cousins and Lawson, 2007, p.312) and quality problem solving (Lo and Yeung, 2006, p.213; Holland, Gaston and Gomes, 2000, p.239). Cooperation should be transparent, asymmetric and mutual (Lambrechts, Taillieu and Koen, 2010, p.98; Lo and Yeung, 2006, p.213). This can be partially achieved through team empowerment, overarching team goals and creative problem solving (Holland, Gaston and Gomes, 2000, p.239).

Open communication

Both words are equally emphasised: *open and communication*. Communication in general is crucial for any relationship to work. Different authors attach different preferences to communication: frequent and genuine (Holland, Gaston and Gomes, 2000, p.239), flexible and open (Lo and Yeung, 2006, p.213) and bilateral (Wagner and Hoegl, 2006, p. 940-941). Open should only not refer to communication but also sharing of information (Hoegl and Wagner, 2006, p. 542-543). In practice, open communication could mean, e.g. teambuilding, social events and supplier conferences (Cousins and Lawson, 2007, p. 312), sharing of product information (Wynstra, van Weele and Weggemann, 2001, p.161), flexibility and openness towards learning and change (Holland, Gaston and Gomes, 2000, p. 239) and sharing of uncertain information (Lo and Yeung, 2006, p. 213). Although communication should be open, it should also be coordinated. Van Echteltn, Wynstra and van Weele (2008, p.196) suggest that there should be communication interfaces designed for the supplier and for the buyer. Gerwin (2004, p. 248) notes that coordination could happen through informal communication, among peers and with the use of teams. Lastly, Hoegl and Wagner (2006, p.542-543) note that the best communication occurs when it is *not* maximized, but when there is an adequate level and intensity of it.

2.2.3.2 Implications for design office integration

More and more suppliers want, or are persuaded, to take part in the design part or the product development part of the host company. More and more suppliers also see the many benefits of this (McGinnis and Vallopra, 1999, p. 5; Bozdogan et al., 1998, p. 171). It is not a huge leap from applying the supply integration theories and results to design office integration. After all, local design offices around the globe are internal customers of the global design office.

The above framework conceptually fits design office integration well. Prospective design offices should be assessed and thoroughly examined before signing any contracts. In the same manner, design offices should be vetted not only for their technical skills but also for their project management and social skills.

Long-term relationships are also very important for design operations, because to be a very good designer one must possess experience and perspective of many things that only experience and learning can bring.

Trust is similarly important for designers. Although it is expected that chief designer in the global design office will check the work of the other offices, the chief designer has to trust that the other designers know their jobs. Furthermore, in many cultures, initial trust must first be gained before open and genuine communication can happen.

Best performance measures are more difficult to enforce in design operations, because with design there are many qualitative aspects that are difficult or impossible to measure. On the other, some kind of monitoring and measuring should be put in place. For example, a simple but informative thing to measure is the rework done in one office. The reasons for the rework may then be investigated later.

Coordination of the suppliers is equally important for design offices. They have to be given boundaries and policies which will guide their decision-making processes. Without them they may make bad decisions, may not do anything or may ask the chief designers about everything. A very good option for coordinating design operations for design offices would be standardization of design where it is appropriate.

Open and seamless cooperation is, of course, very suitable for design offices, too. The same two dimensions mentioned above can be directly applied to design offices: sharing and involvement. Sharing could include sharing of knowledge and assistance, sharing of innovative ideas and recommending better choices for components and suppliers.

Involvement of the design office in developing processes and decision-making could improve the design operations.
Open communication is crucial in design operations because of the considerable amount of uncertainty and the fast pace of change in processes and situations.

2.2.3.3 Problems of the supplier integration model

Although the success factors of supplier integration for new product development are very interesting and confirm, for the most part, the two previous models, they have their own problems. The first, and perhaps the most crucial, problems are the validity of elements of the model and their differences in impact.
The problem is that the topics have been chosen based on the knowledge and experience of the current researcher. Were they really the right choice or could some of them have been deleted and something else added? To answer this question and to understand the right topics, a comprehensive statistical study should be carried out on a number of companies. At the same time, the impact of different topics would be found.
Another risk is that applying supplier integration into new product development to integrate new design offices *in general* may not be valid. But based on the results obtained in this study this is not the case because they are in line with the two previous models. Nevertheless, the risk should be considered when applying the model.

As one can see from the three models (transition to globalized development, virtual teams and supplier integration into new product development), they have similar aspects, but also differ in many ways. In the next section, support for my own model, which is partially compiled from the three previous models, will be presented.

2.3. Combined literature-based model for successful integration of offshored design operations

In this section, an own model is presented for successful integration of offshored design operations based on different literature sources and fields. This is because the only other model found in the literature was published by Karandikar and Nidamarthi (2006, p.1055). Their own revised paper shows the same results (Karandikar, 2009, p.226). Based on my research, their model is lacking in critical aspects and gives only a general idea of what should be done. In the above sections three fields have been studied: global engineering networks, virtual teams and supplier integration. From these, one model is now formed and material added from other studies as well. Following this, each part of the model will be looked at individually in order to assess its role, based on the evidence presently available.

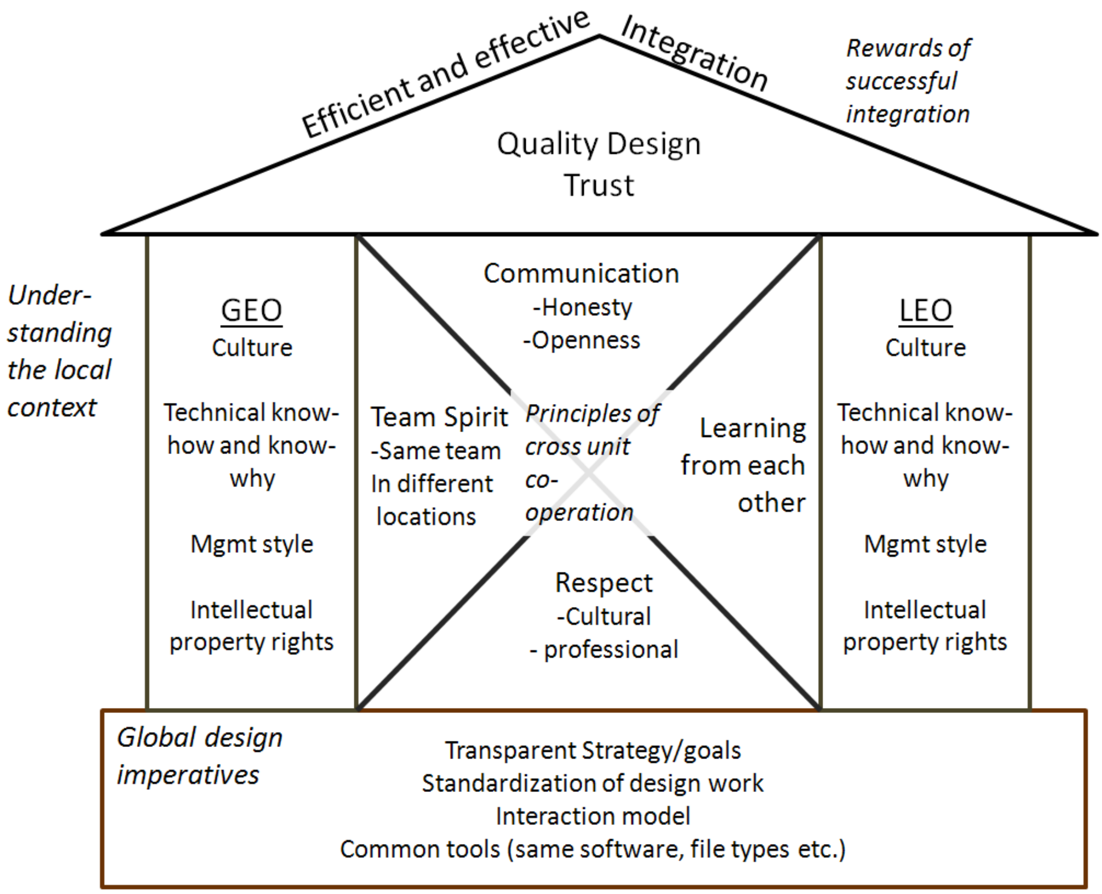

Figure 7 2.3. Combined literature-based model for successful integration of offshored design operations

The model consists of four elements: foundation, walls, braces and roof. The foundation has to be laid in order for the house to be standing. The walls have to be sturdy and well built for the roof to stay on top. The braces have to be strong to support the walls. The roof is the top layer and the reward from the foundation, walls and braces. When the whole house and all of its components function in harmony, the people inside can experience efficient and effective integration.

The next sections are ordered according to the "building blocks" of the model from ground to roof. The topics inside the blocks are bolded.

2.3.1. Global design imperatives

Global design imperatives are the foundation that contains the base tools and practices that many researchers have found to be crucial for global design operations.

Many studies have found strategy to be influential in success for offshoring design. Karandikar and Nidamarthi, (2006, p.1047-1048) found in their three year study of three companies that setting a **global design strategy** and justification for it helped the companies achieve a successful transition from local to global design operations. Similarly, Eppinger and Chitkara (2006, p.147) emphasize the need for companies to carefully consider their own strategies and to choose which components in their product development process should be offshored and which should not. In other words, companies should not just form a global design strategy but do it in the context of their current overall strategy. From their supplier integration research, Ragatz, Handfield and Scannell (1997, p.200) empirically found that for successful supply integration establishing goals is a requirement. Lastly, a design offshoring consultant firm, PTC, (2005, p. 4) states in their white paper that design offshoring companies which do not have a meaningful strategy for balancing cost and value are at level two (there being five possible levels). To get the full benefits of design, offshoring companies have to develop a global design strategy.

Standardization of design work is needed when the design operations shift from local to global. The co-designer is no longer in the next cubicle, but may be on the other side of an ocean. This changes the nature and the required tools to do the daily work. In one classic article about organizations, Mintzberg (1980, p. 324) suggests five coordinating mechanisms: direct supervision, standardization of work processes, standardization of outputs, standardization of skills and mutual adjustment. Regarding virtual team research, Ramesh and Dennis (2002, p. 7) reduce Mintzberg's five mechanisms to three: standardization of processes, standardization of inputs and standardization of outputs. Support for this comes from Karandikar and Nidamarthi, (2006, p.1048). In their empirical study, two out of the three companies studied used a standard solution concept, shared work processes and design rules to achieve successful transition from local to global design operations. Their arguments are based on their article in 2005 (p. 494-495), where they talk about standardization not only in the design context but also in sales and purchasing. Many scholars recommend modularization to standardize product planning in global design (Gokpinar, Hopp, Iravani, 2010, p.4); Eppinger and Chitkara (2006, p.29); Anderson et. al. (2007, p.11); PTC White Paper, (2005, p.9); Makumbe, (2008, p.164)) As Anderson et al. (2007, p.11) suggest, when a product is modularized, it is then possible for it to be transferred elsewhere. In good modularized products all the interfaces are standardized and the modules are assembled independently. This is called the architecture of modularization (Lehtonen, 2007, p.171). Thus, when the interface specifications are published to all of the sites, there is much more probability of success. The probability increases due to every designer dealing with the same goals and knowing the minimum needs for the whole system to work. It also gives autonomy for the individual offices to decide and create their own sub-systems in the right context. Similarly, the modularization concept can be used in the organization's processes as well (Eppinger and Chitkara, 2006, p.29; Ma, Tong, Wang and Xu 2008, p.1; Seol, Kim, Lee and Park 2007, p.178). Specific tools for standardization are Ward's (2007, p.137-140) trade-off curves. They were developed in Toyota and are used as a basis for their product development. A trade-off curve is an A3 sheet where one or more failure modes are written as a graph. The graph is a simple two-dimensional diagram, which plots one or more parameter(s). The advantage is that they are very simple and easily understood globally, but very dense in terms of past design knowledge.

Interaction model means that the company has a documented way of working in global design operations. It could chart, e.g. how the approval process is done, what the responsibilities of the offices are and how the designers in different locations share assignments. In their article about software offshoring, Cusick and Prasad (2006, p. 22) include the same thing as "established policies and procedures" to their model "key success factors". Karandikar and Nidamarthi, (2006, p.1048) have the same notion. They call it "work structure". They mean it only as communicating (to the employees) how the transition from local to global design operations will affect the employees. There is, however, an imperative to widen the scope and document *all* the aspects of global design. It is not only because of control, but when a company offshores more of the design operations, it becomes more complex in detail and more complex dynamically.

Common tools are a necessity to perform global design across different working environments and time zones. In the literature studied, there were few references to common tools. This may, however, be because it is simply common sense to have the same tools, for instance software, file types and shared model database. The closest reference found was in a model by Ragatz, Handfield and Scannell (1997, p. 200). They talk about different assets (intellectual, human and physical) that make the supply integration successful. One of the points regarding physical assets was "shared plant and equipment". That, in the context of design offshoring integration, can be translated as using the same tools and platform across locations.

When the above four items work together, the different locations in the global design network understand why and how they work globally, know how to interact efficiently with the other locations and have the tools and guidelines that everyone shares.

2.3.2. Understanding the local context

By definition, global design means that two (or more) design offices are going to be in a different geographical area. From the current literature selected four factors have been selected which have the most impact on global design integration. They examine the dualism which underlines global design co-operation. I define the host or the lead design office, usually in a high cost country, as Global Engineering Office (GEO). The corresponding office at the low cost country I refer to as a Local Engineering Office (LEO).

The first definition in the Merriam-Webster dictionary of **culture** is "the integrated pattern of human knowledge, belief, and behavior that depends upon the capacity for learning and transmitting knowledge to succeeding generations" (Merriam-Webster, [online]). Because the country and office cultures in GEO and LEO are different, the way they perceive things, behave and work are also different. Many of the articles that I have read emphasize that culture has a great impact on work (Gokpinar, Hopp, Iravani, Bilal Gokpinar, 2010, p.3; Distefano and Maznevski, 2000, p. 49 and Makumbe, 2005, p 118). In Makumbe's interviews of global leaders in multinational companies (2005, p

118) many of the managers brought up “culture as an important variable in global product development”. Some managers said that it is crucial to teach people and share awareness. After people trust each other, culture is not a key factor anymore. Distefano and Maznevski (2000) in their study of global teams, say it is important to understand the *differences* between teams. The differences can be in thinking and learning styles, or profession. When the differences are known, it is much easier to prevent any negative effects of them. Mar-Yohana (2001, p.8) presents a quote from one manager that illustrates the role and the need for understanding cultures: “Get to know the culture of the country... the working culture... projects management (style)... problem solving process. Forget about what you are and what you’ve done, and listen to what they say. They might not be right or wrong, just different”.

Almost by definition, GEOs, by having a long history and long designer careers, possess tremendous amounts of knowledge and unique information about the product, customers and practices. However, almost by definition, LEOs have almost nothing of that because most (if not all) are new to the company, the product and customers. This is why the expectations of what the new office can do must be on a realistic level. There should be mapping and training of current **know-how and know-why**. Know-how is about how we do something; e.g. how one should design columns to a mobile machine so that it does not collapse under maximum stress. Know-why is why something should be done *like it is done*; e.g. why the steel of the column should be according to an industry standard (Garud, 1997, p. 81). Many implications come from understanding this difference. If the GEO or local trainers only teach know-how, the learning curve will be considerable flatter than to teach know-how alongside know-why.

Because global companies are made up of people, they have to have **leaders and persons who are globally skilled and oriented**. Because future integration and engineering managers have to lead global engineering and R&D projects and to handle disputes between different design locations, leaders have to become globally smart. Gregersen, Morrison and Black (1998, p.22) quote the now retired CEO of General Electric, Jack Welch:

> "The Jack Welch of the future cannot be like me. I spent my entire career in the United States. The next head of General Electric will be somebody who spent time in Bombay, in Hong Kong, in Buenos Aires. We have to send our best and brightest oversea and make sure they have the training that will allow them to be the global leaders who will make GE flourish in the future.”

Companies need these global leaders because managers should not use the same management style in domestic and global contexts (Mar-Yohana, 2001, p.8; Gregersen, Morrison, Black, 1998, p.26). Gregersen, Morrison and Black (1998, p.22-28) list the requirements of a successful global leader: unbridled inquisitiveness, sincere interest in others, being a great listener and understanding different viewpoints, understanding and balancing dualities (e.g. adopting local vs. head office practices) and being street and business smart. Mar-Yohana (2001, p.8) recommends global managers to use

Hofstede’s cultural dimensions as *guidelines* to see the main differences in cultures and help adjust one’s management style accordingly. The words “guiding lines” are emphasized because Hofstede’s dimensions have serious flaws when used rashly. They should be understood fully before applying them.

Anderson et al. (2007, p.16) mention information leakage as one of the risks in distributed product development. The risk is that, when sharing information and articles with a third-party partner, they can be sold (under the table) to competitors. The same risk is expressed by Aron and Singh (2005, p.141). They emphasize the planning phase of offshoring in order to tackle **intellectual property** problems, but also say that “there is no sure way organizations can protect themselves …” (also in Ghelfi (no year, p. 7). In the American University Law Review (Yu, 2006) there is an extensive updated article about intellectual property rights in China. This is taken as an example because, as Karandikar and Nidamarthi, (2006, p. 3) state,, the intellectual property rights management issue has not been addressed in the literature extensively. Yu argues that the cause of the problems in China is the ancient Confucian culture, which emphasizes rituals and traditions to keep peace and order, not legal matters (Yu, 2006, p.970). Of course, enforcement of the intellectual property laws is lacking, but also a myriad of new laws has made it difficult to enforce them (Yu, 2006, p.975). Ghelfi (no year, p. 13) recommends companies should have an “integrated and holistic intellectual property policy”. In practice, that means identifying all intellectual property material, taking measures to cover licensed intellectual property assets, finding out what kinds of contracts and policies your vendor has with its vendor and finding out your vendor’s customers (Gelfi, no year, p. 11). Yu suggests some novel approaches to battle intellectual property right infringements in China: education and isolation. Yu suggests educating the workers or suppliers in how intellectual property protection works and why it is important. This sounds too simple, but Yu shows that one of the problems in China is simply that culture and society are founded on principles so different that the understanding of the principles of intellectual property rights should not be taken for granted (Yu, 2006, p. 955-960). By isolation, Yu means simply that firms should isolate the design or manufacturing of key technology and make them local in order to better control the intellectual property environment (Yu, 2006, p.965-969).

2.3.3. Principles of cross-unit co-operation

The braces illustrate the actual tools and practices between GEO and LEO which are needed to achieve cross-unit co-operation. They are the means for the locations to understand each other, resolve conflicts and improve cooperation.

Modern engineering activity is fundamentally about **communication** with internal and external customers and articles which are needed for the design and the output of the design process (Perry and Sanderson, 1998, p.1044). Because distributed engineering is in its nature spread across different cultures, time zones and practices, communication has assumed a critical role in successful integration (Karandikar and Nidamarthi, 2006,

p. 4; Hameri and Nihtiki, 1997, p.2). This criticality is suitably shown in Anderson et al's Stock & Flow diagram as below (Anderson et. al. 2007, p.9-10). One can imagine the box in the middle to be a barrel, which fills little by little with interruptions, which are caused by communication errors, late information, lacking honest communication between suppliers, etc. All of them add interruptions to the barrel and they cause integration problems. Of course, these integration problems add even more interruptions to the barrels on top of the old ones. This creates a vicious circle that keeps getting worse. On the other hand, *if* the amount of output from the barrel is large enough, e.g. there are templates and facilities to achieve quality communication over time zones and cultures, honest and partnership based dialogue is encouraged from the management with suppliers and other groups. Thus, the output (i.e. the tap from the barrel) is so big that there is no accumulation happening and there is no vicious circle.

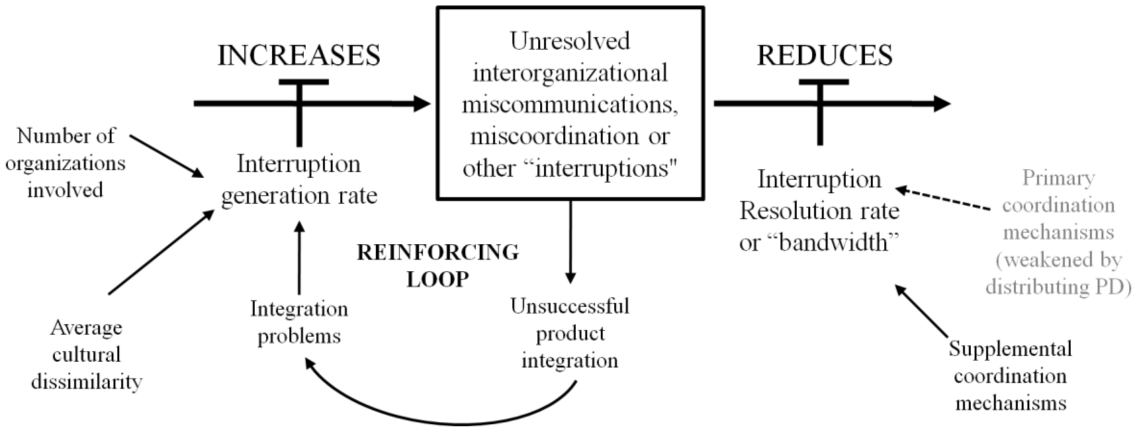

Figure 8 Stock&Flow diagram of the reinforcing loop of interruptions (Anderson et. al. 2007, p.10)

Mishra, Sinha and Thirumalai, (2009, p.11), tested the hypothesis of face-to-face time of engineers regarding their technical efficiency in global projects. They found that face-to-face time has the effect of "a statistically significant increase in technical efficiency of a project". Makumbe (2008, p.143) argues that "water cooler" (informal) talk is very important in overall communication. However, in distributed development there is no "water cooler" talk, apart from when engineers are in face-to-face talks. He recommends that "water cooler" talk is added to the interaction between team members. Senge (2006, p.232) talks about the defensiveness which occurs when people are diffident and reluctant to have conflicts of interests and opinions. Defensive practices work as a protective shield around our deepest assumptions and beliefs. The biggest problem with defensiveness is that most of the time people do not recognize it in themselves or in others. The defensive routines can be broken by being open, continuously assessing one's assumptions and asking honest questions (Senge, 2006, p.238).

Studies have found that globally distributed teams have weaker relationship bonds than "normal" teams (Powell, Piccoli and Ives, 2004, p.10 and McDonough, Kahn, Barczak, 2000, p.115-116). This is why **team spirit** needs more attention. It is clear that when teams are functioning well, their output is also better. The design of a complex machine requires the whole design operation to work as a team. Many scholars recommend frequent face-to-face meetings as a prerequisite to forming a healthy team (McDonough, Kahn, Barczak, 2000, p.115-116; Mishra, Sinha and Thirumalai, 2009, p.11; Makumbe, 2008, p.143). In broader terms, Jarvenpaa and Leidner, (1999, p. 806-807) found that social (electronic) messaging forms trust within the team. Social communication is especially important in forming relationships at the beginning.

Very close to team building is the practice of **learning from each other**. Support for learning and sharing knowledge comes from Aron and Singh's (2005, p. 137) basic assumption that operations that are offshored will not perform as well as ones performed in-house. This is because the "old" knowledge is not in the new location and the people are new. Karandikar and Nidamarthi (2006, p.1049) suggest focusing on *two-way* information exchange between locations instead of only the GEO, with extensive knowledge, advising the LEO. They also suggest that learning happens slowly, moving from simpler tasks to more complex ones, through rotation of people and readily available access to documented engineering know-how. Global design teams, being virtual, can also apply Robey, Khoo and Powers' (1999) arguments on learning in virtual teams. Basically, they reported that through good communication in open social environments people learn just by interacting with each other. In their longitudinal empirical study on how distributed teams learn from others despite functional and distance boundaries, Sole and Edmondson (2002) found special aspects of locally and remotely situated knowledge. The fundamental difference between these is the ease with which workers can acquire the needed information, remotely situated knowledge being harder to find and understand. The authors identified two important aspects of situated knowledge: awareness and appropriability (Sole and Edmondson, 2002, pp.30-31). Awareness of the locally based knowledge should be highlighted because for "non-natives" the local knowledge is "invisible". Appropriability means that once knowledge has been found, whether it can be used in the new context correctly must be verified. To improve the situation, the authors suggest technological environments to improve the awareness of local knowledge, moving key personnel to different locations and that managers convey historical knowledge through documented stories (Sole and Edmondson, 2002, pp.31-32).

A major benefit from mutual **respect** comes from the respect of other's assumptions that result in different behavior (Maznevski and Distefano, 2000, p.203). From understanding different assumptions, our own and others, we can have productive discussions about any matter (Senge, 2006, p.173 and 189). Respect for the differences of other people is the foundation of collaborative virtual teams working together (Janssens and Jeanne, 2006, p. 127).

2.3.4. Rewards of successful integration

The roof symbolizes the combined results from the foundation, walls and braces. Arguably, when all the sections in these three elements work together, global design teams can enjoy trust while producing quality design work. That is also the goal of this thesis: to have the GEO and LEO work well together right from the beginning. For the design team to work together, trust is very important to gain and sustain from the beginning (Jarvenpaa and Leidner, 1999, p.792).

Quality design comes from the combined effect of the model. When designers understand the “big picture” of strategy and they have the right tools and practices to do their daily work, a foundation which the designers know will support them is laid down. When the designers understand that many things in their work depend on perspective and context, it gives them insight into and understanding of the differences in others. When this is combined with honest and open communication, mutual respect, a sense of working in a global team and shared learning, the design teams in every location will have been integrated with each other to do great design.

2.3.5. Shortcomings and Implications of the combined integration model

The combined model tried to unite three fields: global engineering networks, virtual teams and sourcing integration. The goal was to have a model for efficient and effective design team integration.

The first problem comes from the fact that there was no empirical evidence regarding what was selected for the model. The selections were made based on the researcher´s own deliberation and the apparent needs of design office integration. Thus, the model should be tested for its validity in empirical settings.

The second problem also has to do with the selection process. Many things affect a successful design operation, team working and integration. A number of important subjects had to be left out of the model. Again, an empirical analysis of the impact of the omitted items and subjects should be made.

Despite the shortcomings above, it is believed that the model has some advantages over the previous, Karandikar and Nidamarthi (2006, p. 1046) model of integrating global design operations. First, it takes subjects from other fields and adds them to the model. It also widens the scope to include a wider range of aspects than Karandikar and Nidamarthi’s model. For instance, because communication plays a huge role in design teams, this aspect should be emphasized. Second, the importance of cross-unit co-operation principles is recognized. The individual offices are very ineffective without guiding principles to unite them in task and personal levels.

The model should help global managers and other practitioners to focus on leverage items of global design integration, and it also functions as a support in focusing on the things that are found to be working (in theory). For instance, the model can function as a justification of some new HR practices when hiring new managers and designers for global operations, but most importantly it also gives the important functions that should be in place when considering offshoring design operations.

The final section of the second chapter includes a critical examination of offshoring design operations risks.

2.4. Risks of global engineering operations

It is very important to look at the risks before embarking on a new journey. Mishra, Sinha and Thirumalai (2009) found that risk management planning increases the technical efficiency of a distributed project organization’s projects. Furthermore, Aron and Singh (2005, p. 136) state that companies think more about their country, city and vendor options and do not think nearly enough about the risks of offshoring. Some companies do not even think about what kind of processes they have. From the three basic categories core, critical and commodity, only the last one should be offshored. When dealing with the core processes, companies should think long and hard about the risks and benefits. It has to be emphasized that it is important to acknowledge that it is almost certain that the LEO *will not perform as well as the in-house design team* (Aron and Singh, 2005, p.137; Mishra, Sinha and Thirumalai, 2009, p.22)).
In this section the risks are divided into three different categories: environmental, structural and operational Risks.

2.4.1. Environmental risks

Environmental risks mean risks which do not originate from the offshoring process or the offshored company.
The argument can be made that when we ship development and engineering to low cost countries, competitors learn how to make the same products and drive the host company out of business. PTC claims just the opposite will happen: when low cost countries get more knowledge and wealth, they drive up the demand for higher quality, western products. At the same time, when low cost country engineers get more knowledge, they can do higher and higher skilled engineering, hence, freeing engineer manpower from those jobs to even higher level engineering in the high cost countries (PTC White Paper, 2005, p.11).
Vestering, Rouse, Reinert and Varma, (2005, p.5) mention many critical risks, which can be seen especially in low cost countries: political risk, lack of enforcement of intellectual property rights, currency risks, impact of natural catastrophes, terrorist attacks (p.3) and economic crises (p. 3). The article recommends mitigation strategies, i.e. that companies should balance the risks with the capabilities and advantages of the country (p.5).

2.4.2. Structural risks

The HBR article warns companies not to place too much trust in vendors. The risk regarding vendors is that they can stop investing in training or in quality people after a year or so. This is because at that time the host company relies fully on the vendor (Aron and Singh, 2005, p. 140). Aron and Singh (2005, p 140) suggest companies can create a buffer of service after the contract period is closed and, if possible, split the needed work in two different offices so the other always knows that the host company can transfer the work away. The buffer of service helps companies to select a new provider in case of foul play if there is a long time for a process to stabilize. The same risk is discussed by Anderson et al. (2007, p.16). In addition, they note that when a supplier notices that it has no competition, innovativeness can also drop dramatically, leading to an even worse situation.

Another risk, close to the above, is the "loss of component expertise". This risk is about offshoring all component design and manufacturing to a vendor. This leads to a situation where it is very possible that understanding of the technology is compromised. This has two effects: "First, the ability of the lead organization to monitor the supplier becomes compromised, often leading to an increased component price for the host organization. The other effect is that the reduced component expertise interferes with proper integration of the component into the product as a whole." The mitigation strategy for this is partial outsourcing. This means that the critical components are kept in-house and then the bulk components are outsourced. This also creates the opportunity to pull back all the outsourced components if needed, because the company has not lost the capability to understand the technology. (Anderson et al., 2007, p.17)

The only structural risk is that employees of the host company are afraid of losing their jobs, and because of this their productivity and morale will decrease (PTC 2005, p.12). At the same time, keeping quality employees can be very difficult. Karandikar and Nidamarthi, (2006, p. 4) and Michael and Christoph (2005, p. 2) confirm this risk. The answer that the PTC paper gives is that globalized engineering is not a matter of choice anymore, because competitors are already offshoring to low cost countries. In order to stay competitive, companies need to move to low cost countries in order not to go bankrupt. That said, it has to be remembered that PTC sells offshoring services. Karandikar and Nidamarthi's risk mitigation technique for this was presented in their model in detail (see 2.2.1).

2.4.3. Operational risks

Aron and Singh (2005, p.141) define the operational risks as all the problems which occur because of the distance and the delegation of assignments. In other words, how to battle the lack of knowledge at the offshored site compared to the onshore host office before the learning curve catches the offshored site. They recommend two strategies: "documenting work that employees do…", and "…use of metrics to measure quality of processes."

The first is called codifying work. Codifying means that workers write down what they do, how they do it and what kinds of responses they execute for different scenarios. This eases the offshoring work and reduces the risk of closing down departments in the host countries before the offshored location knows how to do their work. They remark that not all work can be codified, and the question is whether they should be offshored at all. (Aron and Singh 2005, p.137-138) An obvious problem, which is not talked about in Aron and Singh's article is, what responses to codifying requests will be received from employees. The risk of increased employee turnover is arguably a very possible result from codifying. On the other hand, codifying is not so different from standardization of engineering work because there, too, employees have to write what they do and how they respond to different engineering problems. Perhaps the real difference is how one presents the request. Standardization of engineering work also helps engineers, because they free their own brain capacity and time from always thinking about how to tackle the problem. Instead, they simply read the instructions and execute them. Thus, the brain work is focused on solving the problem with already-made tools, not thinking what tools should be used to solve the problem.

The second operational risk mitigation tactic is using metrics *before* offshoring in order to factually verify the performance, efficiency and savings *after* offshoring is done. They sum up the claim by saying: "what a firm does not measure, it cannot offshore well". They suggest that if there are no metrics before the offshoring, the company should create them, measure in-house for a while, improve performance and then offshore. They also emphasize that, in their experience, if companies impose subjectively laid out metrics, they end up with costly errors. Therefore, companies should make tolerance limits for errors, impose productivity norms, draw up completion times and continuously measure employees' performance. (Aron and Singh 2005, p.138-139).

One of the most critical operational risks is intellectual property infringement. Intellectual property rights management is previously discussed in Section 2.3.2. However, it must be pointed out here that according to Aron and Singh (2005, p.14) "There is no surefire way organizations can protect themselves against this risk unless they set up dedicated facilities offshore." This statement has to be kept in mind when we move on to the results section of the thesis.

3. CONTEXT

The main purpose of this chapter is to show the nature of customer project design. This is imperative for this thesis because design office integration is targeted for this kind of design. In addition, the chapter shows many of the problems which are faced in Cargotec's global design operations. This chapter presents the results of the interviews and problems with the current design operations with other design offices around the world.

Cargotec is a Finnish company with business all over the world and sales of 2.5 billion euros. Cargotec employs about 9,500 people worldwide. It has small sales companies and different sizes of manufacturing and design branches in many parts of the world. Cargotec consists of three brands: Kalmar, MacGregor and Hiab. Kalmar's business is to develop, manufacture and sell the whole range of mobile and stationary machines needed in small and big harbours for container logistics.

Kalmar has its main design office in Tampere, Finland. In addition to this, it has smaller design offices in China, India and a new one in Poland.

A RTG (rubber tired gantry crane) is a mobile harbor logistics machine. It is made for transferring containers from container trucks to storage and to highway trucks. It is popular in low cost areas and when high storage capacity is required. Usually, it runs on big diesel engines, but electric power is gaining in popularity. It has three basic engineering areas: mechanical, electrical and automation. In this thesis, I focus only on the first two. It has very strict standardization in both areas, but especially in mechanical design. Every aspect has to be according to customer country standards. It is basically a modular machine.

Figure 9 Rubber Tire Gantry Crane (RTG)

3.1. Present customer project design processes

All the Rubber Tire Gantry Cranes (RTGs) are partly custom designed for every customer. A project can include one or more RTGs, but they are all identical inside the project. A typical project starts with a production order, which is made by the sales department. The production order is a document which includes all the information about the functions needed in Cargotec's order-to-customer process. When a production order is made and revised to be accurate, the main bill of materials (BOM) is created. The making of the main BOM is the same as designing all the necessary modifications to the machines. Typically, the main BOM is created from already known components and other items. The assistant chief engineer said that about 90% of items are easy to add to the new main BOM because they are already created. The remaining 10% have to be designed by designers. The design work for the remaining 10% is usually divided between two different design locations: Finland, China; and in the future, Poland. According to the project engineering manager, the design work is distributed according to the destination of the product and the workload in the locations.

3.2. Information systems

This section introduces the platforms and software that designers use. The point is to show what kind of tools they use in their work and to show what kind of obstacles they face with them.

3.2.1. Auric (PDM-system)

The whole information system at Cargotec is a mix of old and new systems from different companies. Auric was originally just a small document storage system, but grew to be the dominant database for all documents and other items (soon to include 3D-models). The user interface of Auric lets users search different databases and open items. Files can be attached to items. Auric is hugely important for designers because practically all the information about every item in the machines and projects is there.

Auric is perhaps the most crucial program for designers and managers at Cargotec. Auric has all the item information, BOMs, all project documentation and drawings. Soon it will also include design change orders. After this, Auric will be the single system for engineering. On the other hand, some of the interviewees expressed cases of Auric being unreliable. For instance, the item transfers between CEI and China’s design office are sometimes not completed, and the fact that there is no report indicating if the transfer has been successful makes things worse. Also, the 3D-model transfer, which sends from Auric to, e.g. CEI, has a relatively poor reliability record. One designer said that he “uses huge amounts of time manually copying models to CEI”. This is a huge waste of engineering time and talent. Another problem regarding Auric is that of viewing a drawing or a 3D-model from India, which takes minutes to open, if it opens at all. The speed of information networks has to be on par with the GEO.

Persons outside the network need a virtual private network (VPN) connection to access the systems in Cargotec. For instance, Finnish design offices need a VPN connection in order to see the material in Cargotec’s drives and extranet.

3.2.2. Software

Five designers were interviewed from customer project design to understand the tools that designers use. The interviewees took the form of daily, or almost daily, talks via email or calls to other design offices. My aim was to find out exactly what kinds of things mechanical and electrical engineers need in order to do design work.

3.2.2.1 Essentials

All 3D-modeling is done with Catia V5 -software. Electric design (only 2D) is done with E3-software. In Tampere, all the 3D-models are in a network folder. When 3D-models are needed in India or in China, a person with the rights authorizes an item to be transferred to the other location. Nowadays the transfer happens 16 times per day with RTG models. According to the interviews with three mechanical designers, the transfer protocols work quite inconsistently. Some problems are caused by Auric and some occur due to slow network speeds in India or in China.

Cargotec uses Office Outlook, Communicator and LiveMeeting as their main internet based communication tools. 2007 Outlook has some convenient features, e.g. very well integrated calendar and time management software. In addition, if the LEO has the same version of Outlook, they can share each other’s calendars and send meeting requests directly to each other’s calendars. Office Communicator is similar to the consumer directed Messenger. Communicator is a text based real-time conversation tool, but it also has other features. It has voice and video over the Internet capabilities and direct file sharing. LiveMeeting has similar features to the Communicator because they are very integrated. LiveMeeting can host conference calls and file sharing with many attendees and share programs and create co-operation polls and documents. It also has a feature which allows the other party to “take control” of the other’s computer. This opens great opportunities to, e.g. show what should be changed directly on a 3D-model, and because both parties see the same screen directions can be given clearly. The feature also allows easy explaining of complex documents to people. Due to different locations at YC, designers are quite comfortable and used to the basic tools (text, voice and file sharing), but the more complex tools (e.g. desktop sharing) are not in frequent use. This is due to lack of knowledge and experience of the features of the tools.

3.2.2.2 As needed

One of the interviewees, a strength analysis specialist, stated that it would be ideal if all the designers could have GPS (Catia’s Generative Part Structural Analysis 2) to verify their basic designs. The GPS tool is simple to use and can analyze assemblies. The other two tools that the specialists use are much more difficult and require specialist knowledge. When asked, he also stated that in the Chinese design office they use GPS as well. Important benefits from using the simpler analysis tools are raising the understanding of strength analysis and its problems, better overall design and learning between special skills (Thomke 2006, p.30).

3.2.2.3 Information search

When asked where and why designers search for information, they usually say from people around the office. The use of standards is common, but not usually the first choice. Google also comes up as a search tool for suppliers’ product information and for their 3D-models.

Flow is a website which shares information with the whole of Cargotec. For instance, from Flow one can find a Cargotec-wide phonebook, cafeteria menus, information and news about Cargotec and a lot of instructions and guidelines and some standards. According to my talks with the designers, however, not many of them use Flow as much as they perhaps could. Team Sites on the other hand, being integrated with Flow, are used much more. Team Sites is a document database for individual projects or subjects. Examples would be a development project and a list of standards respectively. It also contains different kinds of instructions and manuals, a Catia V5 manual for example. Next, let us next examine what kind of standards Cargotec has.

3.3. Standards and work instructions

3.3.1. Standards

The unification of standards at Cargotec is an on-going process. The goal is that all of the brands of Cargotec would use the same standards. According to a standardization development engineer, this leads to savings, best-practices, reliability, improvements in quality and the safety of the products. Before the unification process at Cargotec, Kalmar tried to unify its standards under KGS (Kalmar Group Standard). It partially succeeded, but now when there is a need to get all of Cargotec's standards unified, the problem is unresolved. According to the standardization development engineer, agreement with unified standards comes quite easily to other members of the Cargotec family because as a basic rule ISO, or other internationally acclaimed standards, are always the default choice. If there is no international standard, the group has to resolve it by negotiation.

Quite a big problem is, according to the standardization development engineer, the fact that the standards are not Cargotec's property. The copyright belongs to the standardization organization. In Finland, that organization is SFS. SFS forbids, without paying extra, to give the standards to other parties under different management in the same company. For instance, the standards bought from SFS in Finland are forbidden by copyright law to be given to the China design office, although they are the same company as in Finland. SFS sees China as a different organization because they have different management.

In Sweden, things are different. According to a standardization development engineer, Swedish Standards Institute (SIS) has given permission to use the standards bought there to be used in different countries within the same company. The Polish design office will need all the necessary standards right from the beginning. The odds are that SIS is a better channel for getting them.

3.3.2. Work instructions and other created documents

Unlike the standards, work instructions are created by the employees or contractors of Cargotec. Thus, Cargotec owns the rights to them and they can be used when needed. Based on the interviews with two RTG project designers, all of the work instructions for RTGs are attached to their project BOMs. Thus, every RTG project has its unique BOM, which includes painting, packaging and other instructions. In addition to the project specific instructions, all over Cargotec's information platforms (mainly in Flow) there are manuals and instructions for software, platforms and Cargotec policies. Their problem is that they are so spread out that finding them can be difficult.

A problem that persists after many years of globally distributed design and manufacturing is that some items in Auric are found only in Finnish and especially some of the item description texts are in Finnish. This has some obvious implications for designers outside Finland.

Below there is a summary chart, which shows the findings of this chapter in cross-reference to the combined theoretical model.

Table 2 Cross-reference chart of findings in this section with the combined theoretical model.

Combined theoretical model	*Information Systems*	*Standards and work instructions*
Global design imperatives		
Transparent Strategy/goals		
Standardization of design work		Most of the standards are location specific and design instructions are tacit knowledge
Interaction model		
Common tools (same software, file types etc.)	Existing, but also software problems and slow network connections	
GEO and LEO (local context)		
Culture		
Technical know- how and know- why		Much tacit knowledge only in Tampere
Management style		
Intellectual property rights		
Principles of cross unit co-operation		
Communication	Tools for easy global communication exist	
Team Spirit		
Learning from each other		Cargotec does not have a shared design database. Thus, learning is very distributed and not managed
Respect		
Rewards of successful integration		
Quality Design		
Trust		

4. RESULTS: REQUIREMENTS FOR THE INTEGRATION FRAMEWORK

The previous chapter examined the context and every-day situations that designers face when doing global design operations. In this chapter, the subject is continued, but from a more specific perspective. The perspective is what things are *specifically* problematic with integrating the outside design offices to the main design operations in Tampere. This is done, first by observing the situation in general in Tampere, then in China and then in one of the Cargotec's brand companies, MacGregor.

4.1. The state of LEO integration

4.1.1. Tacit knowledge

Cargotec's quality process developer told me that before 2006, the year that Kalmar finished their factory and design office in China, there was no need for design office integration. All of the design for RTGs was being done in one place, the Tampere office.

When it was time to start co-designing with the China office, the Chinese did not get anything done because of missing information and lack of access to Tampere's files. In addition, some of the documents were in Finnish. Because of this, Cargotec sent two engineers to the China office to guide and teach them. In practice, they carried the tacit knowledge with them to China in order to make the China office operational.

Tacit engineering knowledge is everywhere at Cargotec Tampere. Engineers use notebooks to save information regarding their actions. There is no database to store knowledge that is generated when doing design work. Cross-department knowledge transfer happens quite randomly, according to the interviews. It can happen when formal training, problems or customer complaints occur.

A quality manager at Cargotec emphasized that every system and tool that Cargotec uses has to be transparent and global. Transparent, because then people know what is happening and what is the current state of a document, drawing etc. Global, because the information has to be the same everywhere and accessed by everybody. In other words, no multiple copies should exist of the same objects and no global information should be in local network hard drives.

4.1.2. Unique practices

Based on interviews with many managers, one process level problem for integration is the soon-to-be-replaced old processes which are, if written down, unique for every brand and sometimes unique for every design unit. E.g. a design unit in Sweden has a different process for order to assembly or a different way of adding information to drawings. Thus, as the standardization development engineer said, a manufacturing worker or assembler has to know how to *interpret* a drawing differently according to where the drawing has come from. This creates dangerous situations in global manufacturing because the tacit knowledge regarding the different practices will most probably not reach everyone. Drawings must always be clear. This is the reason that Cargotec is now reviewing and creating only one way to do things for all of the brands. The one overarching process will cover all the processes which are available for everyone with access to the Cargotec's Management System. As one can easily understand, although the process maps are revised into one overarching process, this does *not* mean that employees will change their working practices to the new ones. On the other hand, it is always necessary to start from somewhere.

After every section of the fourth chapter there will be a summary chart which shows the findings of the section in cross-reference with the combined theoretical model.

Table 3 Cross-reference chart for findings in this section with the combined theoretical model.

Combined theoretical model	The state of LEO integration
Global design imperatives	
Transparent Strategy/goals	Ongoing work for unifying the Cargotec-wide process
Standardization of design work	No common standards across locations
Interaction model	
Common tools (same software, file types etc.)	Every tool has to be global and documents in the same system
GEO and LEO (local context)	
Culture	
Technical know- how and know- why	A lot of local tacit knowledge in Tampere
Management style	
Intellectual property rights	
Principles of cross unit co-operation	
Communication	
Team Spirit	
Learning from each other	
Respect	
Rewards of successful integration	
Quality Design	
Trust	

4.2. Learning from the China design office

In this section, I introduce Cargotec's design office in China. This particular case was selected because it is the most recent completely new design office to be established. It also changed the design operations in Tampere from only local design to global design. This had many implications.

Cargotec's China design office (CDO) was established in 2006 nearby Shanghai. According to different managers, at first there were only a few Chinese engineers at the CDO. This did not work at all as they did not have nearly enough knowledge or even the resources from which to learn. This was because there were no knowledge databases or even access to Tampere's network drives. Soon after realizing this, two experienced Finnish engineers, a mechanical and an electrical engineer, were sent to live in China for two years to lead and assist the Chinese engineers.

I interviewed the Finnish chief mechanical engineer who was in China leading the change and now runs localization projects. When he arrived in China, the whole Shanghai operation included a multi-assembly unit (MAU), sales, a buying department, and the engineering office, whose main responsibility was to do customer project design and some troubleshooting regarding the problems found at the MAU. For the first two to three months the chief engineer taught the CDO's two engineers. After three months the CDO employed more designers and the two Chinese engineers taught the new ones. This, said the chief engineer, worked very well.

The main problem was that there was not enough information available to do the design work. The chief engineer said that about 75% of all the problems regarding design were problems of not getting needed information or the difficulty of finding it. He and the other Finnish engineer were the only persons who had direct access to the files at Tampere and had the rights to transfer them to CDO. He told that when leaving Finland to move to China he had taken "all the necessary files and documents that I thought that we would need". Even after that he had to make continuous transfers. Documents from Auric could have been transferred from the main database in Finland to China in few hours, but the models took all night because the system runs models to different folders at night. This had many implications. First, it took the chief engineer's time from everything else. Second, it was very frustrating and distracting for the Chinese engineers to work in this way.

4.2.1. Problems regarding information and models

According to the chief engineer, there was no serious planning done regarding how the day-to-day operations worked at CDO before opening the office. This affected every aspect of the operations, but was especially significant in issues regarding information flow. At that time, quite a large number of items in Auric were in Finnish. Some items had no additional information beside the name. For instance, one item could have been just called “a screw” and then the number of the item. The chief engineer said that the screw’s information could have been found in an Excel document in the network hard drives in Tampere, or some people “just knew what that screw was and where it should be”. This obviously does not work after design operations have gone global.

A tiring issue for the chief engineer, when leading the CDO, was that a lot of information had to be inputted by hand to different Auric databases because there were inconsistencies between the two databases and no automatic way of doing the same thing. He concluded that all information has to be well processed so that it is easily accessible.

According to the chief engineer, the other Finnish manager in China and the customer project manager, the reason for not having enough or the right information in CDO was that *all* of the information was regarded as top secret. They said frequently in the interviews that one of the key things in getting information management right is to classify information correctly, i.e. the classified information *really* needs the classified label. Excessive classifying is a huge waste of time as most of the items in RTG need not necessarily be hidden or restricted from other designers. For instance, all the mechanical parts, excluding gearboxes and motors, are so easy to copy with a measuring tape that there is no need to restrict them. Most of the electrical items are just bought components, e.g. sensors or switches, which are simple enough to be copied with the naked eye. A 3D-model of a metal plate is hardly worth the price of confusing and slowing design. Even big assemblies are, on one hand, understandably restricted, but what happens when a designer designs a new part and does not see the big picture easily. Thus, it is essential to define what items, models and documents are justifiably restricted from common use.

An additional problem concerning items is that all of the brands and some design offices have different items and item numbers for standard unimportant items. For example, the same bolts and screws can be listed three times in Auric as different items from different offices. This, according to the chief engineer, should be made uniform. This, in turn, would make work easier at LEOs.

4.2.2. Support from Finland

A PDM system specialist, who is in constant interaction with CDO, stated that the support from Finland was good in giving advice and information to China, India and Poland when needed. She was not aware of fear of losing jobs from Tampere, but claimed that if it existed, it did not obstruct the operations. Not all Finnish designers were supportive towards their Chinese colleagues at first, but when the situation was fully realized by them, the co-operation got better. She hoped that there would have been more support for solving small disputes with little operational value. Most often the disputes came from people not wanting to give up own routines. She concluded that when the different parties got to know each other better, most of the small petty disputes became easier to solve. The chief engineer said the same thing. Getting to know the other person better always helps co-operation. He insisted that they did not put enough time into that at the beginning of CDO operations.

The PDM specialist also said that the Finnish designers have understood the fact that all information regarding an item has to be fed into Auric in order for the part to be problem free. Without all the necessary item information in English, a global company cannot function. If a designer does not fill every required field in Auric, the problem will come back and it will have to be done later anyway.

4.2.3. Using key users

A key user is a person who has responsibilities to consult with other design offices regarding his/her specialist area. The chief engineer and the PDM specialist said that they found this to be a good way as the key user focuses on the other person's needs, has clear responsibilities and forms a relationship with the other party. On the other hand, one R&D manager told that if the key users are overworked, the key user system does not work. Furthermore, the key users create bureaucracy due to the hand-out of the tasks.

4.2.4. What did we learn from CDO?

Information systems have to be easy and efficient to use. The Polish design office has to use the same Auric database as Tampere to avoid problems originating from different databases and items out of sync with Auric. The PDM specialist emphasized the importance of cultural awareness in co-operation. The role of culture is very important (Makumbe, 2008, p. 118; Mishra, Sinha and Thirumalai, 2009 p. 11). As the chief engineer said, "one has to balance between cultures; what to bring to the other organization and what to keep". This is especially important in China due to vast cultural differences, but it also plays a part in Poland. The tendency of Finns usually saying what they mean and keeping their promises is, in most other cultures, not the case by default. The PDM specialist said that most of the cultural problems are essentially trust problems, which become less significant with time and interactions. The PDM specialist needed the authority to solve yes-no deadlock arguments, which use a lot of energy and delay what would normally be small decisions.

Cargotec has many communication tools to use. First, they have Office Communicator, which is similar to Messenger. One can send text-based messages as well as attach photos and other files. For bigger or more complex talks there is Live Meeting software in Microsoft Outlook. This can be used to talk via the Internet and share files. For the biggest and most important events, there is a video conference room. Employees are generally quite satisfied with the existing communication tools. It is not enough that Cargotec uses the same communication tools; they also have to be used in the same way (Makumbe, 2008, p. 139).

Of course, none of the tools can replace face-to-face talks between persons. The chief engineer stressed the importance of face-to-face communication between parties, especially at the beginning of the relationship. Face-to-face communication forms the badly needed personal ties and image of the other person. It also transfers valuable tacit knowledge. There should be no hesitation in sending designers to other locations. These arguments are confirmed by other research findings (Makumbe, 2008, p. 143-144; Mishra, Sinha and Thirumalai, 2009 p. 23).

Covering one's own or other's mistakes and problems can be a serious problem in some organizations and cultures. When asked about this, the chief engineer told that they had encountered surprisingly little of this. He said that the Finnish managers continuously emphasized from the beginning that "errors and mistakes are allowed, but trying to cover them up leads to problems with the management". He said that an active and clear take on communication from the beginning is crucial in order to direct office culture in the right direction.

Table 4 Cross-reference chart for findings in this section with the combined theoretical model

Combined theoretical model	Learning from China Design Office
Global design imperatives	
Transparent Strategy/goals	No practical strategy communicated for CDO, failed initial execution
Standardization of design work	No common standards across locations
Interaction model	
Common tools (same software, file types etc.)	CDO had no access to the files or models of the Tampere office, because of the fear of intellectual property infringements. Software and communication tools were good
GEO and LEO (local context)	
Culture	Most employees jump to higher paying jobs very easily Generally, cultural problems lessen with time Cultural awareness training needed
Technical know- how and know- why	The initial knowledge of the designers was lower than expected The transfer of tacit knowledge was non-existent or very slow
Management style	The Finnish managers had to teach the Chinese managers first and these then taught the Chinese designers Attention to special things, e.g. mistake handling
Intellectual property rights	Fear of intellectual property infringement slowed the design work considerably because the 3D-models were not accessible
Principles of cross unit co-operation	
Communication	No authority to handle disputes between offices, but generally supportive and warm relations. Face-to-face meetings are very important
Team Spirit	Face-to-face meetings support the creation of team spirit
Learning from each other	Two engineer managers had to be sent to CDO to transfer knowledge
Respect	
Rewards of successful integration	
Quality Design	
Trust	Trust accumulates with time and builds up relationships and smooths over conflicts

4.3. Learning from MacGregor

4.3.1. MacGregor as a business

MacGregor was chosen to be the second case study because it was good to have an "outside" view for the subject. Although Macgregor is part of Cargotec, its business is very different to Kalmar's and due to its history it has very different processes and ways of doing design. On the other hand, as it belongs to the same company, it can share needed information with Cargotec.

Two interviews were conducted at Macgregor. The first one was more general in nature and the second more specifically about global design. The first interview was with a design manager and the vendor manager, who is responsible for all the design partnerships at MacGregor. In the second round of interviews, only the vendor manager was at present.

MacGregor is one of the brands in Cargotec. MacGregor designs, sells and manufactures cranes, hatch covers, Ro-Ro (roll in – roll out) and cargo lashing equipment for different kinds of ships. In addition, it also makes linkspans, Siwertell bulk handling cranes and equipment for terminals and ports.

4.3.2. Design at MacGregor

MacGregor is very different to Kalmar in the sense that it does not do any manufacturing of its own. Thus., to the customer they sell a complete solution but MacGregor is, by and large, an engineering office. Furthermore, MacGregor's design department directly employs only design managers who do the main concept and design work for solutions (e.g. hatch cover system design). The design models (2D or 3D) are then sent to Cargotec Engineering India (CEI) or to the Chinese Design Office (CDO), where work drawings for the models are made. After this, a subsidiary manufacturer in China makes the physical parts and assemblies. MacGregor has made long-lasting partnerships with its subsidiaries. The design managers are also project managers with responsibility for the success or failure of the project (MacGregor's vendor manager).

The way MacGregor uses its global partnership network and design managers suggests that they are at level 4 and 5 of the maturity levels mentioned in Section 2.1.2.1. They distribute work tasks around the globe seamlessly, but still do the main concept design at one location. Thus, MacGregor is a front to the customer without having most of the functions in-house.

4.3.2.1 The way of doing design outside

Because of the differences in products compared to Kalmar, MacGregor defines every design need for outside engineering office as a complete package. The company defines the assignment, the requirements and, finally, the price for the design. With the CEI and CDO they cannot get a package price and they are "constantly fighting over the right price of an engineering hour" in these two locations. The on-package approach has the advantage that MacGregor can define the need and the quality. If the supplier cannot achieve this, MacGregor can send the design back and demand rework for free. With CEI and CDO, because they are owned by Cargotec, all the rework is usually just added to the total price. The vendor manager preferred package pricing to hourly pricing.

The selection process to get new design offices is quite straightforward: first, possible offices are mapped and the work and the product that will be required introduced. Then a test project or a pilot is set up . If all goes well negotiating a standard price is started. The pilot is important and a good way to measure know-how. It also shows the suppliers what kind of design will be needed from them, and scales their promises down. The manager said that "all engineering firms promise the earth". The manager noted that it is very important to decide how the design price will go down, when the designers learn more about the work and the product. For example, after 5 projects the price will decrease 20% and after 10 it will be decreased another 20% or so. He emphasized that this has to be done *in the beginning* of the contract. There is a very slim chance of getting the discount later.

Another emphasized point was that MacGregor uses quite exact standards for drawings. The manager said that this was crucial because different design managers want to do things "their own way". When standardized, the same symbols and styles are always similar for manufacturers to interpret. The "standards" have to be specific and agreed upon by *all* the design managers to get engagement.

4.3.2.2 Specific points

The manager was asked different questions about what the literature and the previous results have found to be problematic.

Sharing 3D-models

When asked how they give 3D-models to CEI for them to do work drawings, he said that the Finnish designers use the same server the designers at CEI use. With the CDO things are very different. Trust in the China office is really low. He said that "In China, our drawings are already in the hands of the competitor". This is why they still do not know what to send to China. Apparently, they send only fragments of the model to China and use CEI much more than the China office. At MacGregor, they have the same lingering problem as at Kalmar. They do not want to send models to China, because they know that they will be sold. However, they have to give something in order for the CDO staff to be able to do their work. In both places, the interviewees say that "something should be done about that. We should settle this once and for all in a big meeting". The vendor manager's idea was to get the "intelligence" out from the 3D-model. Then the model could be shared. He warned that it was very important not to give the customer interface to other locations. This prevents, e.g. a Chinese manager from setting up a new business.

Sharing design knowledge

MacGregor has compiled a database for engineers about different design knowledge. It is called Design Guidance. The vendor manager said that Design Guidance is a good start, but the handling of the database is big work and would require a full time person to manage it.

When asked about the ideal state of Design Guidance, he replied that “it should contain only essential information and it would be short and dense, but also inform the reader when s/he cannot use Design Guidance”.

MacGregor has developed its own standards, which are based on ISO standards. As they are owned by MacGregor, they can be distributed as MacGregor sees fit.

MacGregor design managers visit customers, i.e. shipyards and terminals, with almost every project. They also have visited manufacturing sites and design vendors. Designers at the China office regularly visit the manufacturing vendors because they are located nearby. The vendor manager concluded that, in his mind, it is enough for the design managers to have *adequate* knowledge about customer requirements. For other designers, e.g. CEI designers, it is enough to understand the operational environment. He emphasized *adequate* because he knows that the design managers like to endlessly refine their designs, but this is costly for MacGregor. He said that “the best designer for the customer is the worst for the company”, meaning that if the designer did “perfect” design, it would be *too* good. The design has to be *suitable* for the customer and for the company. Thus, there ought to be some supervision, training and guidelines for determining when a design is suitable.

Evaluating design offices

For evaluating design offices MacGregor uses the CROL (Customer Relationship On-line) -process. CROL is a customer feedback process, which is a web-questioner and conducted bi-annually. MacGregor uses the CROL for customer and material supplier feedback and also for getting feedback and data for their design manager – sales manager and design manager – engineering team (offshore teams, e.g. CEI) relations. For the design manager – sales manager relation, the questioner asks, e.g. is the information transfer from sales to design clear enough and sufficient. For the design manager – engineering team relations the questioners asks, e.g. if the design manager is giving clear tasks and whether the design manager is giving enough information to help the engineering team.

The vendor manager also emphasized that the in-house designers rarely see a problem in themselves. It usually is the other person’s fault. This is why it is important to have an outside referee to make an impartial analysis about the problems in their co-operation. The partnership has to be transparent and clearly communicated. For instance, regarding transparency, project deadlines have to be put in place and communicated not only to the design vendor, but also to the design manager so both parties understand the situation. Then, if the design manager is late for the first internal deadline the vendor cannot be expected to be on time for it.

In addition, he said that the host company has to give time for the vendor designers to learn the product and its special features. In his estimation, with MacGregor products, this takes 3-5 years. This is the case especially with emerging countries such as India and China, because their culture of modern engineering is so young. Therefore, the bad quality of design has to be understood for a long time. On the other hand, he said that if the design vendor is making bad quality because of indifference towards good design, it is a different matter. For instance, if the vendor is making errors in the design because they can make more money from correction hours, it should obviously not be tolerated.

Reaction against offshoring from design managers

MacGregor has been doing offshored design for 10-15 years already. MacGregor faced all the usual reactions against offshoring, especially the fact that some of the designers were fired, but also the fact that the design team was not in the next cubicle anymore. The latter is still brought up by the design managers when things go wrong.

The vendor manager said that it was crucial to emphasize the good things from offshoring and the real need for it. For example, when we offshore part of the design, the company can have profitable and competing products. Another fact is that the only real competitor to MacGregor is an all-Chinese company. Because of offshoring, they now have the price of the products on a par with them. According to the vendor manager, the savings from doing design offshore at MacGregor are about 50% compared to an all Finnish designer network. Furthermore, especially with smaller order batches, the design hours are a considerable part of the total cost.

Problems with CEI and China

The vendor manager listed some problems in CEI and in China. I present them here as an example of some of the problems that may be faced in Poland, too.

With China, in addition to the ones already mentioned, the problems are lack of knowledge about strength calculations, difficulties in correcting their own mistakes and also the lack of trust in their capabilities.

In CEI, the designers are seen as taking too much initiative and overdesigning (e.g. doing too much detailed work on something that does not need it), difficulties in changing their own 3D-models and, as opposed to their Chinese colleagues, Indian designers have too much confidence in their capabilities.

It has to be noted that after describing the above problems, the vendor manager said that the designers in both locations are young and most of them have no experience in this kind of design, so it is important to be patient.

Success factors

When asked about specific success factors for achieving a coherent design offshoring network, the vendor manager replied that the work is never finished. He listed the first meeting between the design manager and the sales representative, (Microsoft Office)

LiveMeeting, fairly frequent visits between design offices, document standards (e.g. in drawings), cost goals *before* the start of the project, top managers' devotion to the offshoring network idea and, most importantly, engagement from the design managers in the offshoring network.

4.3.3. What can be learned from MacGregor?

The key thing about MacGregor is that it is operating in a way that, very possibly, Kalmar will be doing in its design work in three or four years. The new competence center, which is going to be built in Tampere, is forecast to be a hub for higher level design and R&D.

Important lessons are that the support and engagement from the managers and the design managers in the offshoring of design are essential. Also, one has to understand that the designers in India and China need considerable time and effort to learn the product and the design environment.

Because of global design, different backgrounds, different cultures and different personalities, the standardization of design documents is crucial to avoid miscommunication and misunderstandings.

The in-house designers' feelings have to be considered and the case for design offshoring made clearly and with facts. Without their co-operation nothing will happen.

When running into problems in the design network, the first thing to do is to look into a mirror and then investigate the causes of the problems.

Table 5 Cross-reference chart for findings in this section with the combined theoretical model

Combined theoretical model	Learning from MacGregor
Global design imperatives	
Transparent Strategy/goals	Clear vision of how global and distributed design works in practise Long-term view for design partnerships Top managers are committed to the global design operations
Standardization of design work	System for common design practises made and developed
Interaction model	Semi-defined way of doing global design CROL process gives a feedback loop for the interaction.
Common tools (same software, file types etc.)	They verify the same tools by doing a pilot design case before signing a contract
GEO and LEO (local context)	
Culture	Trust in the China office is very low
Technical know- how and know- why	Sharing of technical knowledge only local. Common global standards Big gaps in knowledge outside Finland
Management style	
Intellectual property rights	Big problems of protecting their 3D-models and design knowledge. This is true especially in the case of China.
Principles of cross unit co-operation	
Communication	Information is going almost only from top to bottom LiveMeeting praised
Team Spirit	Designers rarely meet, but they have formal feedback processes (CROL)
Learning from each other	
Respect	
Rewards of successful integration	
Quality Design	Emphasis on Design managers
Trust	

4.4. Summary: requirements for the integration framework

The requirements and problems of integrating design offices at Cargotec have now been reviewed. The current state and problems of the Tampere design office regarding global design, points and conclusions about what things went wrong when setting up the China Design Office and what MacGregor does differently to distribute its design globally have been presented. After every section above a chart has been presented which cross-references the points found in the section with the theoretical model. Based on the problems found in Cargotec Tampere regarding global design imperatives it is clear that the company needs to develop and communicate their vision and development plans better. They must have a clear direction and tools to control the complexity which arises from global design operations. Based on the interviews and found problems it is also clear that designers and managers should be taught much more on the different contexts of GEO and LEO and bring those differences to surface. When the different contexts are clear to both locations, then the principles of co-operation can show to people how to make the best use of them. In order to achieve all this, employees and managers need concrete tools and processes to guide them. The next chapter will present a framework and tools to do that.

As a summary, all the previous summary charts will now be presented together, in order to see the bigger picture and requirements for design office integration.

Table 6 Summary: requirements for the integration framework (continues in the next page)

Combined theoretical model	Information Systems	Standards and work instructions	The state of LEO integration	Learning from China Design Office	Learning from MacGregor
Global design imperatives					
Transparent Strategy/goals			On-going work to unify the Cargotec-wide process	No practical strategy communicated for CDO, failed initial execution	Clear vision of how global and distributed design works in practise Long-term view for design partnerships Top managers are committed to global design operations
Standardization of design work		Most of the standards are location specific and design instructions are tacit knowledge	No common standards across locations	No common standards across locations	System for common design practises made and developed
Interaction model					Semi-defined way of doing global design CROL process gives a feedback loop for the interaction.
Common tools (same software, file types etc.)	Existing but also software problems and slow network connections		Every tool has to be global and documents in the same system	CDO had no access to the files or models of the Tampere office because of the fear of intellectual property infringements Software and communication tools were good	They verify the same tools by doing a pilot design case before signing a contract
GEO and LEO (local context)					
Culture				Most employees move to higher paying jobs very easily Generally the culture problems lessen with time Cultural awareness training needed	Trust in the China office is very low
Technical know- how and know- why		A lot of local legacy standards in use at Tampere	A lot of local tacit knowledge in Tampere	The initial knowledge of the designers was lower than expected The transfer of tacit knowledge was none existing or very slow	Sharing of technical knowledge only local. Common global standards Big gaps in knowledge outside Finland

(Continued from the previous page)

Combined theoretical model	Information Systems	Standards and work instructions	The state of LEO integration	Learning from China Design Office	Learning from MacGregor
Management style				The Finnish managers first had to teach the Chinese managers , who then taught Chinese designers Attention to special things, e.g. mistake handling	
Intellectual property rights				Fear of intellectual property infringement slowed the design work considerably because the 3D-models were not accessible	Big problems of protecting their 3D-models and design knowledge. This is true especially in the case of China.
Principles of cross unit co-operation					
Communication	Tools for easy global communication is existing			No authority to handle disputes between offices, but generally supportive and warm relations Face-to-Face meetings are very important	Information is going almost only from top to bottom LiveMeeting praised
Team Spirit				Face-to-face meetings support the creation of team spirit	Rarely designers meet but they have formal feedback processes (CROL)
Learning from each other		Cargotec does not have a shared design database so learning is very distributed and not managed		Two engineer managers had to be sent to CDO to transfer knowledge	
Respect					
Rewards of successful integration					
Quality Design					Emphasis on Design managers
Trust				Trust accumulates with time and builds up relationships and smooths conflicts	

5. PROPOSED SOLUTION

The previous chapters have tried to answer the question: in which way would efficient design office integration happen and what are the requirements for it? I have studied the literature, made my own theoretical framework and studied practical example cases. In this chapter a practical integration framework is introduced, which has been created based on the research of this thesis, and two tools are introduced to support and guide the integration framework. The tools will later be examined in more detail.

5.1. Creating an integration framework for Yard Cranes operations

One of the main results of this thesis is a framework which defines the actions and tools for efficiently integrating new design offices with Cargotec Tampere's operations. Tampere is a global engineering office (GEO), which means that in GEO there are R&D and design managers who direct the design assignments globally. Local engineering offices (LEOs) basically receive the assignments and execute them. The Cargotec design offices in India, China and Poland are all LEOs.
The integration framework presented here limits itself *only* to the scope of the thesis which is outlined in the introduction to the thesis. In short, the integration framework only deals with Cargotec-owned, mechanical or electrical customer project design (not R&D) located in a low-cost country. I use the word "framework" in the sense of a suggested model process that Cargotec could use. When talking about an "integration process", this is meant as a general process that Cargotec will have despite the suggested framework. The framework is developed from the reviewed theory and interviews in Cargotec. The framework was cross-checked continuously with the interviewees and with the future owners of the process.

The integration framework (see Appendix 1 or figure below) is divided into three phases and two zones. The three phases are survey, sharing and verification. The zones are meant to indicate on which side, either GEO or LEO, the action is done. If an action is in the middle, then it should be done in full co-operation. The customer for the model process is the design department which implements the process. This is because the design department sends the material to the LEO and then uses the output to understand the situation of the LEO better.

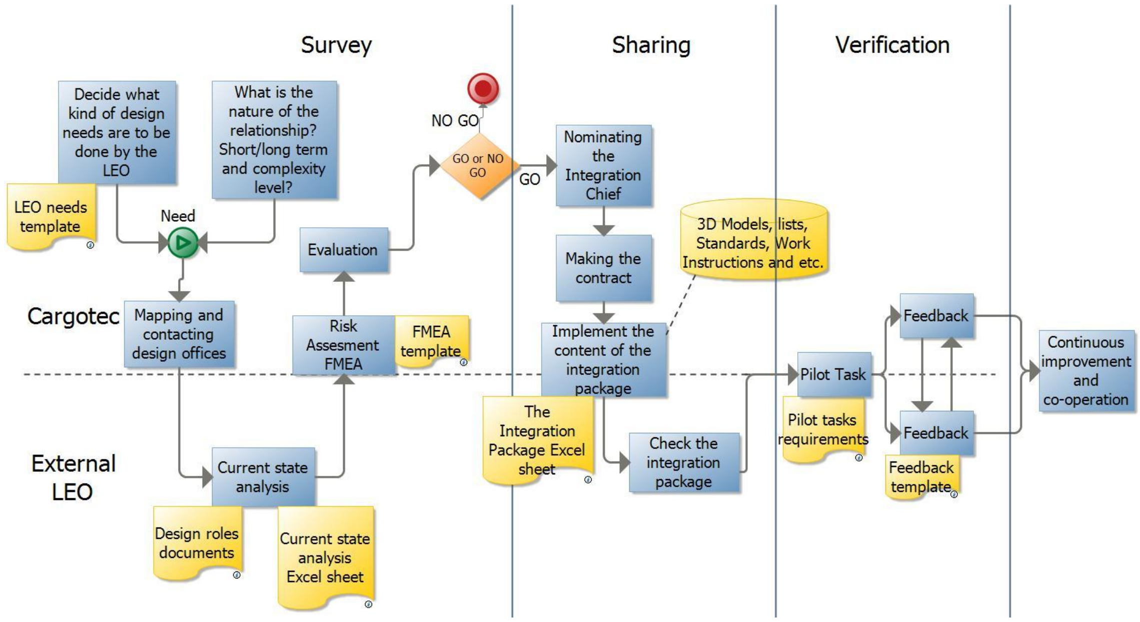

Figure 10 Integration framework for offshore design offices

The reason for the integration framework is to guide future integrations to be more efficient and reduce the chaos and loss of time caused by poor planning, lack of tools and processes. The goal is to reduce the overall time which is needed in order to form unified relationships and practices between LEO and GEO. The figure below illustrates the benefit. In Chapter 6, the test results on the success of the model process are presented.

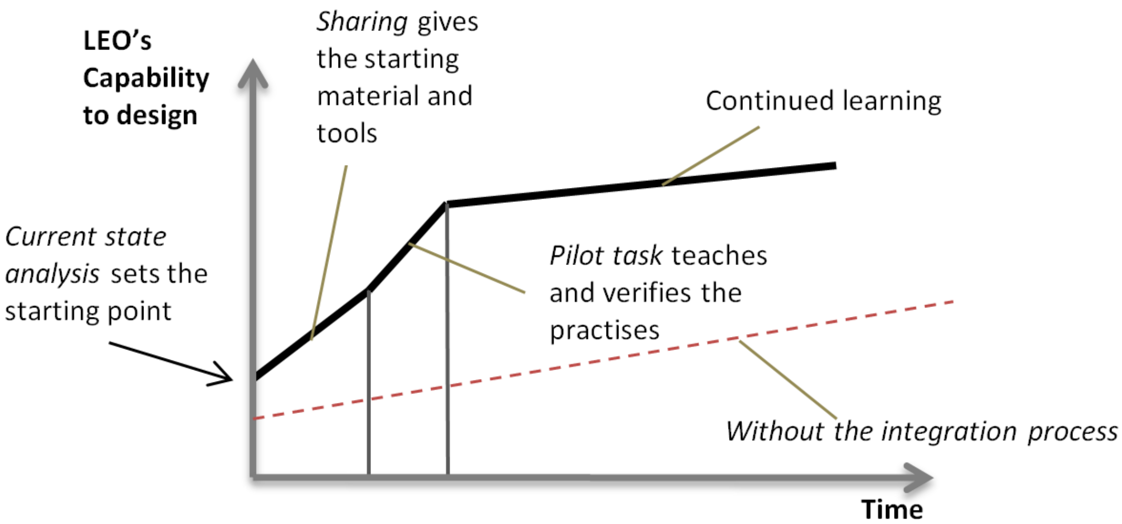

Figure 11 LEO's capability to design with and without the integration process

5.1.1. The integration framework and combined integration model

The integration framework and its tools are directly related to the combined theoretical model which is discussed in Section 2.3. Basically, the integration framework connects itself to the global design imperatives (the foundation) by requiring managers to understand their need for offshoring (strategy). The rest of the global design imperatives are connected to the integration package and the interaction model, which is introduced in Section 5.4. The starting point of the local context (walls of the model) is the current state analysis (CSA). The integration package (IP) delivers the practical side of it by trying to convey the local context of the GEO to the LEO. The principles of cross-unit cooperation (the braces) are mainly communicated and put into practise by the interaction model. However, parts of it are delivered by the CSA and IP. A summary of the findings and links regarding the framework and the model is found in Table 7.

Table 7 Summary of the findings and links regarding the framework and the model; FW-“phase” = Framework and after it is the name of phase.

Combined theoretical model	Integration framework for offshore design offices
Global design imperatives	
Transparent Strategy/goals	Understand the needs of the new office and the timeframe in which the partnership will happen (FW -Survey)
Standardization of design work	Maps the needed common standards which are needed for the LEO and opens up the access to the common 3D database. (IP) In the future, a common database for general design knowledge (IP)
Interaction model	Understanding the LEO's interaction model and processes (CSA) Signed contract (FR-Sharing) Explaining what is the interaction model at Cargotec (IP)
Common tools (same software, file types etc.)	Checking that the LEO has the same tools and resources that the GEO has (CSA) Giving and checking that the same tools are in place at LEO (IP) The pilot task tests the common tools in practise (FR-Verification)
GEO and LEO (local context)	
Culture	Mapping the risks of different locations (Risk assessment) Formal culture training (IP)
Technical know- how and know- why	Understanding the skills and the experience of individual designers (CSA) Integration package tries to level the resources and the skills of the LEO (IP)
Management style	Communicating "the Cargotec way" for many practical things for the managers of the LEO (IP)
Intellectual property rights	Mapping of the counter measures from the LEO (CSA) Communicating the importance of intellectual property management (IP)
Principles of cross unit co-operation	
Communication	The selection of the integration chief (FR-Sharing) Interaction model guides the communication (IP) Formal feedback process at the end of the pilot project (FR-Verification)
Team Spirit	Budgeted face-to-face meetings and rotation creates team spirit (IP)
Learning from each other	The integration package gives as much information to the LEO as possible (IP) The proposed interaction model should create true learning in both ways (IP)
Respect	Communicating the values of Cargotec, and when designers receive training about other cultures, mutual respect should grow (IP)
Rewards of successful integration	
Quality Design	When the process has been gone through, the result from LEO should be quality design
Trust	Risk assessment before the signing of the contract (FR-Survey) Signed contract (FR-Sharing) Budgeted face-to-face meetings and rotation creates trust (IP)

5.1.2. Survey phase

The survey phase of the integration framework begins when there is a need for an offshore design office. In practice, this means that Cargotec wants to do more specialist design operations that it cannot or does not want to do at the GEO. This is done by a department's design manager with the sourcing department. The managers have to define two things about the offshore design office:

1. What kinds of design needs are required by the LEO? This is needed in order to define the capabilities of the LEO.
2. What is the nature of the relationship? Especially, is the relationship going to be long or short term? Long-term means that the LEO will be given more than just a few assignments. This is required, among other things, to define the investment level for learning and rotation of designers.

After identifying the needs, there has to be mapping of prospective LEOs in the desired geographical and skill areas. This thesis will not go into this process in more detail as it is outside the scope of the thesis.

When the requirements and different options for offices are mapped, they can be evaluated. Current state analysis (CSA, Appendix 2) is a tool that was developed for Cargotec by the current researcher to use to evaluate possible new LEOs. It is an Excel list, which lists different things that the new LEO should has to do to conduct business with Cargotec. It also aims to rank possible offices if there is more than one. In Section 5.2, there is a very detailed description of CSA.

After the CSA, there should be a formal risk assessment carried out by a sourcing manager and the design managers at possible LEOs. The risk assessment, failure mode and effect analysis examine possible failure functions and estimate the impact of the failure. There are also assessment boxes, where one can fill corrective actions against the failure functions and again estimate their impact. The risk assessment could be given to LEO managers to complete, but even better would be for them to do the risk assessment together with a chief designer or a design manager.

After the CSA and risk assessment, there is a formal evaluation of the possible LEOs based on the results of the CSA and the risk assessment. It is then just a matter of ranking the order of the LEOs and then choosing the most suitable one.

5.1.3. Sharing phase

The sharing phase of the integration framework tries to assimilate the new LEO to the GEO's way of doing design. Because the LEO sees the GEO as an internal customer, its duty is to try to assimilate itself to the practices of the GEO. The GEO's duty is to help and support the LEO to rise to the same level of design as fast as possible.

Before that can happen, though, two things have to be done: selecting an integration chief and making a good contract with LEO.

An integration chief is a person who is responsible for the whole sharing phase, from selecting prospective LEOs to deciding that the office is capable for a partnership to normalizing design operations after the pilot task. She/he “owns” the process from here on.

The next task is the signing of a contract. An R&D manager emphasized the importance of making a detailed contract. The contract has to describe general things, such as what will be done if there is a dispute about something. There has to be a service agreement which describes response times, e.g. how long is a report period and what kind of sanctions will be imposed if something fails, e.g. if a report is late. In addition to these, there should be price agreements and other necessary documents.

A tool for the sharing phase in the integration framework is called an integration package (IP). IP is an Excel-document, which lists all the suggested things that the integration of the two offices should cover when setting up a new LEO. The point is that when the new LEO has all the necessary (software) tools, documents and standards, it can do proper design with the GEO effectively right from the beginning. This is done by giving them design instructions, the right design tools, all the access rights they need, material (e.g. 3D-models), etc. “Implement the content of the integration package”, means that in this phase the GEO gives the new LEO the necessary things which are listed in the IP. For instance, the first section of the IP is “Management”. The integration chief gives the named person, who is responsible for executing the section, a task, e.g. “write and communicate the documents listed in the IP under the heading ‘Management’”. The same is done for the rest of the sections.

After all the documents and software are given, the next phase in the framework, “check the integration package”, instructs the integration chief to confirm that all the things listed in the IP have actually been done. When the sharing phase is complete, the new LEO should have all the tools, documents and items that they need to start designing efficiently with the GEO.

5.1.4. Verification phase

The verification phase is meant to verify the effect of the integration package. This phase is also the responsibility of the integration chief. The verification is done by giving the new LEO a pilot task. The pilot task should be complex enough that it verifies all aspects of the IP and gives the LEO a sense of the required design quality level. The pilot task should have a mechanical and an electrical side to it. For instance, on the mechanical side, the pilot should test the drawing skills, understanding of basic mechanics, some special cranes standards and feeding items to Auric. It could also lack some key information so that the LEO has to contact the GEO. This will show that the communication works. The detailed content of the pilot task has to be applied case by case and with the GEO designers.

After the pilot task there should be a formal and guided feedback session in both offices. It could be done, for example, with the CROL process that MacGregor uses. The point of the feedback is to get the rough edges away from the relationship and to standardize practices right from the beginning. Because the relationship is new, the feedback process should be supported by a face-to-face meeting or some other social event.

The last activity in the model process is the continuous improvement of the partnership. It is very important but outside the scope of this thesis. It simply means that the new relationship, processes and practices between LEO and GEO should be improved continuously. In addition, after each time a new LEO has been integrated, there should be improvement made to the model process and its tools.

If the whole model has been gone through, the new LEO and GEO should have the same tools, documents and sources. The LEO should be able to do their work efficiently and with quality. The day-to-day work between offices is supported by the integration chief, who also acts as a “referee” if there are problems or disputes. There should be continuous improvements to the interaction model and the work practices that the LEO and GEO now share. If there have been problems in the integration framework, the framework and the tools should be refined and improved.

A summary of the proposed solutions within the context of the framework, tools and the theoretical model can be found at the end of Chapter 5.

5.2. Current state analysis –tool

Current state analysis (CSA) is a tool that analyses the local design office (LEO) by asking questions about its capabilities. The CSA is simply an Excel-form (Appendix 2), which is a checklist for the reviewer from Cargotec to evaluate the prospective LEO.
Of course, it has to be remembered that the whole document is for *guiding* purposes only. There can and should be exceptions and they are in the hands of the interviewer.

5.2.1. Structure of current state analysis

The CSA has nine areas of current capabilities of the prospective design office to map. In developing the CSA, five designers from customer project design were interviewed. The interviewees have daily, or almost daily, talks via email or calls to other design offices. The aim was that they would explain clearly what kinds of things mechanical and electrical engineers need in order to do design work.
The CSA has two levels: office and individual designer level. The office level targets the whole design office, e.g. its processes or software. The individual level targets the individual designers in the design office. This is done because the designers do the actual design work, not the office. It is also very important to understand the exact capabilities of the individual designers.

The following sections are the same as the areas in the CSA. The main point of these sections is to give clarity to the reader when she/he reads the CSA.

5.2.2. Office level capability mapping

The first section of the CSA tries to map the capabilities of the whole office. Although Cargotec hires individual designers, the office can offer more extensive resources and know-how.

Software is the first area of interest. The CSA has a list of software that is used extensively by designers in Cargotec Tampere. The idea is that the reviewer asks the LEO how many licenses of that specific software they have. This gives an overall picture of the software capabilities of the office.

The second area is **network capabilities**. It is crucial that the information network is fast enough and capable of making a direct link to the GEO.

The third area is **hardware resources**. The point is to ask about the LEO's change cycle of designers' computers as well as what kind and how many displays they have per designer. This maps part of the work environment in which the designers have to work.

The fourth area is **HR practices**. This area asks questions such as how many training days the designers had on average and how knowledge is shared.

The fifth area is about the **LEO's design experience**. It asks for the design experience of the whole office. They are asked to give their five best references for each of the categories presented in the CSA. There is also a question about whether the office has any certified project managers, because the leadership in multiple offshored design offices is growing in importance.

The sixth area is about the **LEO's processes**. The LEO has to have defined design processes, including the way they improve themselves and how they make sure that their designs (models, drawings and analysis) are valid and of good quality. All of these are important, because only through defining one's own processes can they be developed or corrected. It also gives Cargotec's interviewer more visual aid in *understanding* how they are working and how the integration with GEO would be done best. Within the process area, there are questions about intellectual property protection at the LEO. As discussed before in the theory part of this thesis, intellectual property management is critical when offshoring or outsourcing. It is expected that the LEO should have some processes, rules, regulations or plans to assure the interviewer about how they combat the danger of intellectual property infringement. Of course, the interviewer also has to judge that the practices suggested by the LEO are within Cargotec's values and within national laws. Related to the intellectual property management is turnover of personnel, as suggested by Karandikar (2009, p.227). It has to be left to the interviewer to judge what acceptable turnover is. A client list of the LEO is asked for to verify that there will be no direct competitors. This is, naturally, more of an issue with an outsourced design office than with Cargotec-owned offices.

The seventh are is a question about ISO **certification**. As a multinational firm, partners also should have ISO 9001or the new ISO 9004 certifications.
The eighth and last of the office level areas is **other**. The only question in this area is where the LEO keeps standard libraries. Are they in a storage facility, printed and stored on a shelf near the manager or in electronic form? This was added based on a request from a very experienced design manager.

5.2.3. Individual designer level capability mapping

The individual designer capabilities are mapped by roles. The roles for mechanical design are different to those for electrical design. The reasoning behind the role based mapping is to simplify the selection process and to make it more specific. One major problem in assessing designers is that it is hard to specify the needs. For this the role template document has been used (see Appendix 3). The role template is a document made for each assessed designer. She/he is assessed by four categories: software and design skills, experience of standards, references and language skills. For every role there are a different number of competences. Competences are finer grained divisions of skills.
A person's experience of different **software** and standards is measured by the years of frequent use.
Standards are selected for each role specifically. All the required knowledge of the standards for that specific role is predetermined by Cargotec designers. In this way, the integration chief can get very detailed and accurate information about the know-how of the designer in question. This should work very well, as crane design is heavily regulated by international standards.
References give important proof of confirmed know-how of the designer from different perspectives.
The assessing of **language skills** is taught, because without extensive tests objective assessing is very hard for non-professionals. In order to have better assessment specifications, the EU's language level self-assessing tool, the Common European Framework of Reference for Languages (CEFR, website) has been used. It is used, e.g. at Tampere University of Technology and has an extensive background theory and practice (CEFR, 2001).

5.2.4. The impact of current state analysis

The CSA tries to guide the assessment of a prospective LEO. It tries to do that at the office level as well as at the personal level. The office level maps the capabilities and resources of the whole office and tries to pinpoint any significant gaps in it. The individual designer level tries to assess a person's capabilities with regard to the required skill sets that the GEO needs. It tries to do that in the most exact and quantitative manner. It also has to be said that the CSA is a living document. With rigorous and thoughtful use, the CSA can be improved and new areas added.

A summary of the proposed solutions within the context of the framework, tools and the theoretical model can be found at the end of Chapter 5.

5.3. Integration package tool

5.3.1. Structure of the integration package

The second practical tool for the integration framework is the integration package (IP, see Appendix 4). The integration package is meant to be a support list for the integration chief. Every section of the IP has its own responsible person and a deadline. Thus, the integration chief is not expected to *do* all the things by himself.

IP is a list of topics and boxes and should act as a confirmation list for what LEOs *have to have* in order to be able to do quality design as efficiently as possible from the beginning. The items in the list are in two timeframes: short and long-term. This distinction has been made because some actions are not justified economically if the relationship is no longer than a couple of assignments. For instance, there is usually no cost justification for rotation of personnel, if there will be no long lasting relationship.

The name of the integration chief should first be written into the IP. Having one leader simplifies the integration process for everybody. The GEO and LEO personnel know who to contact when there are problems or questions. When responsibility and power go hand in hand, it makes engagement much easier.

The structure of the IP is based on different areas: management, rights management and 3D-models, IT, manuals and instructions and the delivery of standards. In every area there are different items which should be dealt with by the named person responsible for the area. For every item there is a prerequisite. The prerequisite tells what should be done in order that the item can be checked as “confirmed”. After every prerequisite, there is a source-box, where the item’s instructions, template, or an example can be found. The sources help in making the documents correctly and efficiently.

5.3.2. Management

The boxes in the Management section of the IP are based, for the most part, on the combined theoretical model here, only a few boxes are presented as an example of the management area.

In the first box there is a task “The responsibilities of different offices are written and communicated”. The different responsibilities of different offices are important to map, write down and communicate to all affected employees. This is to avoid rumors and to minimize fear of losing jobs from the GEO. The second box emphasizes further the role of communication, but from the long-term perspective. Managers should communicate and discuss the long-term view for engineering at the GEO.

The fourth box in the management area is based on the interviews and about creating a healthy culture regarding mistakes. One of the Finnish managers in China said that it is very important to develop the right culture for handling mistakes. In many cases, people prefer hiding their mistakes and covering them up. This is not a good approach at any level of engineering. This is why guidelines have to be explicitly communicated for all of the designers. The manager said it well: “errors and mistakes are allowed, but covering them up leads to problems with the management”.

5.3.3. Authority rights management and 3D-models

Authority rights management is one of the most important aspects of good and efficient integration. If it is done badly, it will waste time, resources and cause discouragement. It can lead to bad decisions if access to information is difficult.

The goal of authority rights management is that everybody involved has enough system rights in the right places. However, need-to-know information should be kept in the hands of the appropriate people. When discussing this, all of those who are involved with LEOs on a daily basis state that rights management has brought much trouble, but of course they also see the point of it. At Cargotec, designers argue that there are too many closed doors where there should not be.

Authority rights management

A separate document was created for rights management. The rights management document is a Word-document, which is a compiled list of all the things that a manager should approve in order for a new employee to start at Cargotec Tampere. It includes hardware, software, folders and other things that should be given attention. It will use the same roles as the CSA-tool. In this way, the roles will become standardized for the whole integration process. The document should be filled in and filed one week before the new employee arrives. There are plans that the document will be added to SharePoint as an intranet website, which sends emails to the right departments and people to activate the access rights and software.

3D-models

One important aspect in design integration is the sharing of models from GEO to LEO. It is important because all mechanical designers need 3D-models to do their work. The topic is very interesting, as companies have to find a balance between sharing 3D-models so designers can work, and on the other hand, not giving too much in order to keep their intellectual property protected. This is quite a controversial topic because the fear of intellectual property infringement is real and apparent, but at the same time designers all around the world should have the GEO’s trust. One of the interviewees said to me that “you have to be able to post the item (model, drawing etc.) to a company’s bulletin board before you can send it to China”. Furthermore, according to two separate sources in Kalmar Tampere and MacGregor, the Chinese suppliers are not shy to boast about our competitors' drawings, asking "why do you not design X like they do?"

The problems are various, but they all spring from not giving access to 3D-models to LEOs. There is a different viewing folder, e.g. for CEI. It is called a privilege folder. One major problem is that the transfer of 3D-models is not reliable enough. One mechanical designer has done many months of manual transfers because there is no knowing if all the models are transferred correctly. This creates enormous amounts of waste in the organization.

Another example is that the reference parts of a model are not transferred with the automatic 3D-model transfer. For example, if a Finnish designer wants to transfer a pump from a motor to the privilege folder to be shared with LEO, only the pump is transferred and the designer has to transfer the other parts, like the motor and all its other parts, to the assembly by hand.

In order to combat these problematic transfers, it is of the utmost importance to *define* which parts are need-to know. With 3D-models the situation is interesting because most of the models are only geometry and volume. Both of these can be measured from a picture or even from a real machine. The true value and business knowledge comes from what the interactions are between parts and assemblies. These interactions usually are not present in the Catia models.

Which models should be on a need-to-know basis, then? Two managers at Cargotec suggested that all models which come out of the R&D department would be automatically freed globally, and only the bigger assemblies would not be. Another option is, as one chief designer suggested, that all *parts* would be freed globally when they come out from R&D. This assures that when any assembly comes to an LEO, Catia can "build" the assembly and its reference parts because it has all the parts.

Also, it must be said that the decision *not* to give the models is not without its costs. The costs from withholding the big assemblies emerge through design errors, wasteful rework, lack of knowledge of the whole system, integration problems and missing information, e.g. from the surrounding parts or corrupting the aesthetics of the machine. One cost is also employee morale: employees clearly see that they are not trusted and that lack of trust is hindering their opportunity to do a quality job (see figure below). The costs have to be analyzed and compared to the intellectual property management risks.

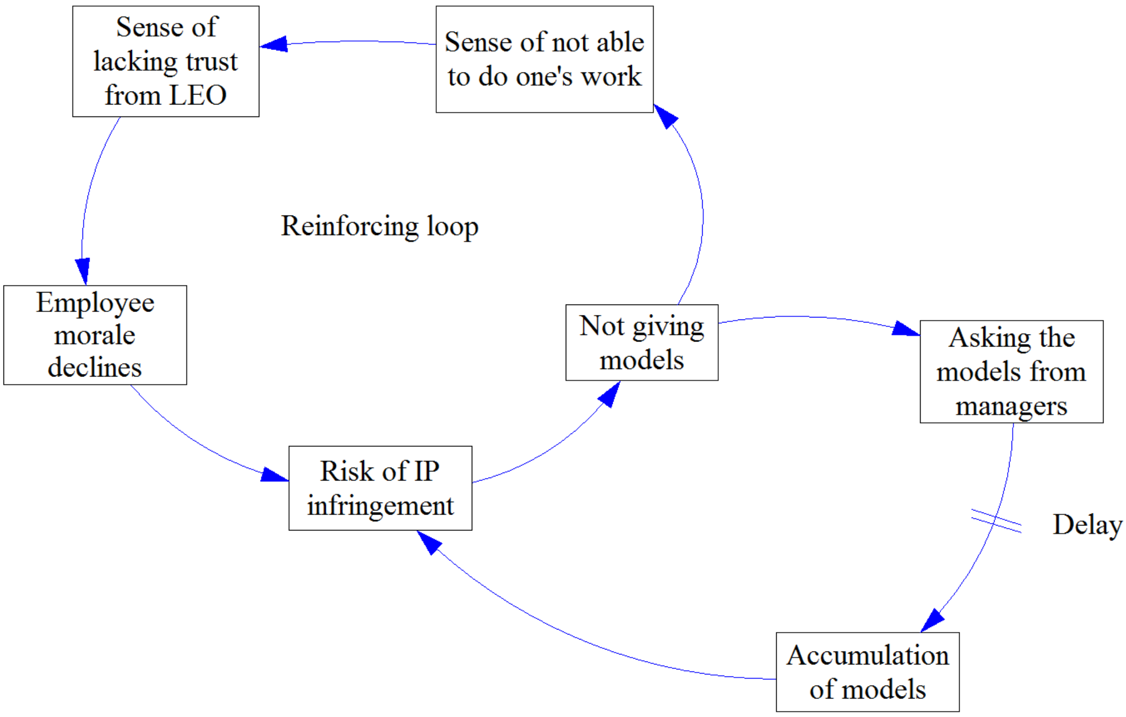

Figure 12 System thinking diagram of intellectual property infringement and 3D-model sharing

Figure 12 shows a loop illustrating (as a system thinking style graph) what happens when there is lack of trust and an intellectual property infringement danger (Senge, 2006). In the graph we can see that when we do not give enough trust to the LEO employees, the risk of intellectual property infringement is a growing cycle. It may be suggested that we should not give *all* the models that we have, but that we should give all the models that they *may need*. Employee morale declines when LEO designers cannot do their jobs well because they do not have sufficient access to the model libraries.

5.3.4. IT

The software topic was covered extensively in the CSA section. Here, the list is meant to make sure that all the necessary software is installed and taught. The person in charge of the verification of software at the LEO ticks the boxes when something is confirmed. Again, the integration chief and the person responsible for software can adjust the needs of the office and individuals for their own situation.

The situation with platforms is very similar to the situation with software. Most of these are very simple, for instance Flow. On the other hand, team sites need more comprehensive care because they are given by the leaders of the individual team sites. Team sites are designated and access rights given in the rights management document.

Network speed and VPN capability are more of a check-up than actual actions, but nevertheless they should be confirmed.

5.3.5. Documentation and lists

Documentation and lists is a section meant to help the responsible person to give *all* the important documents and lists to the LEO. They are all compiled in one Word-document. For every item there is an owner. The topics are: Cargotec (general information about the company and its policies), Organization (specific information about the organization), Product Information (specific information and presentations about the products of the organization), Tool Manuals (places to find general manuals for software and portals), Design Instructions (how to do design in the "Cargotec way") and Other Instructions and Documents (miscellaneous instructions and other material).

5.3.6. The delivery of standards

Defining needed standards

The last area in the IP-tool is a list of different standards. From the interviews it became clear that when using standards, engineers used a lot of very old VLS (Valmet Standardi, Valmet Standard) which contains, as one designer said, "very usable information, e.g. about tolerances, in a convenient form". Some of the VLSs are in Flow but most of them are in Finnish and there are no search functions to find what one might need. I suspect that the use of VL standards is based on old habits and the convenience of the physical folder. According to one mechanical designer, VLS and other old standards, which are based on SFS, ISO, EN or F.E.M., are "not that different to the official ones". This is logical because, e.g. good tolerance values are based on physics, and do not depend on time. Although the old standards are easy to use, they should be replaced by common standards that are the same in all design locations within Cargotec.

After interviewing an expert on strength calculations and mechanical design, it was clear that the French crane standards, F.E.M. 1001 3rd Ed., which are widely used in Europe, are the backbone of the strength calculations for Kalmar's products. Furthermore, the strength calculation professional said that it would be most beneficial if F.E.M. 1001 were more in use for all mechanical engineering. This is similar, though coming from another point of view, to the use of Catia GPS 2 software to analyze mechanical design models and structures. When "normal" designers understand, even a little, the reasoning behind the behavior of the structures, they can design better. The same professional said that in F.E.M. there are instructions on how to make good joints and basic principles about crane design, which could be very helpful in making better structures from the beginning.

As a global corporation, it is an important goal to unify all the standards and their use. According to the quality and standardization development engineer, a Cargotec-wide standards system is not coming any time soon. In fact, there is no schedule for it at all. This should be changed as soon as possible.

Standards matrix

The standard matrix is the last section of the IP. On the left-hand side of the matrix is a list of all the standards in groupings of general, safety and technical calculations. In each of the groupings there are all the standards which are in use in Cargotec's Yard Cranes design departments. Above the matrix there are all the roles from the CSA. In the matrix, there are pre-filled columns to indicate the required standards to be delivered to each corresponding role. For example, if the new LEO has one team leader and two access designers, the integration chief will give the required standards of those roles to the LEO.

A summary of the proposed solutions within the context of the framework, tools and the theoretical model can be found at the end of Chapter 5.

5.4. Creating an interaction model for Yard Cranes operations

Although this thesis focuses on the beginning of integration, the way, in which designers and managers work together, will be decided at the beginning of the GEO-LEO –relationship. Furthermore, one of the items in the theoretical framework was the interaction model.

The interaction model clarifies the way a GEO designer and a LEO designer will do design together. The model emphasizes the process of how designers give assignments to each other. When this interaction is explained and discussed with the future LEO before the actual engineering begins, the LEO better understands how the day-to-day design will unfold. Although the thesis is focused on the start of the relationship, it is important to model, *in advance,* the way designers will do co-operation because it has to be explained to them to get them on board.

5.4.1. Shaping the new interaction model

The model is based mainly on the ideas of Senge (2006). He emphasizes understanding of the whole and focusing not on the individual event in time and space but on the bigger web of events that has a larger impact on the behaviors of people and companies over a longer period of time. He also talks about how to incorporate true learning. There are also hints of the double-loop learning (Model II) by Argyris (e.g. Argyris, 1977, p. 118 and 1976, p. 368-369). The interaction model has been adapted from these two main sources. The model is largely founded on four concepts: using Key-Users (from Cargotec), scope for a longer timeframe, sustainability and real learning.

Let us first examine how the interaction between GEO and LEO is done at present. The conventional way of giving assignments/tasks from the GEO to LEO is that GEO designers try to specify the assignment very clearly and accurately to be sure that the

LEO designer will understand and make the right decisions. The problem is that the GEO designer, with the best intentions, tries to convey his/her experience and knowledge to the specifications but this almost never works. The reason for this is that the GEO designer has a vastly different background and mental models that guide how he/she sees the assignment. He/she has a different cultural background, experience of the products and past designs, much more knowledge about the product and the customer, full access to the Auric database, very experienced colleagues and only a little or vague knowledge about the LEO designer.
Communication is depicted as a message which has to be coded, sent and de-coded by the participant. This coding is done with the specifications and usually by email. Both of these media are very out-of-context tools and require a lot of assumptions and background knowledge in order to be de-coded to have the same meaning as when coded. Herein lies the problem: often the GEO designer’s assignment is understood differently by the LEO designer.

The proposed model is based on not giving more detailed specifications, but giving enough information and (tacit) knowledge to the other designer to achieve understanding of the goal and true learning.

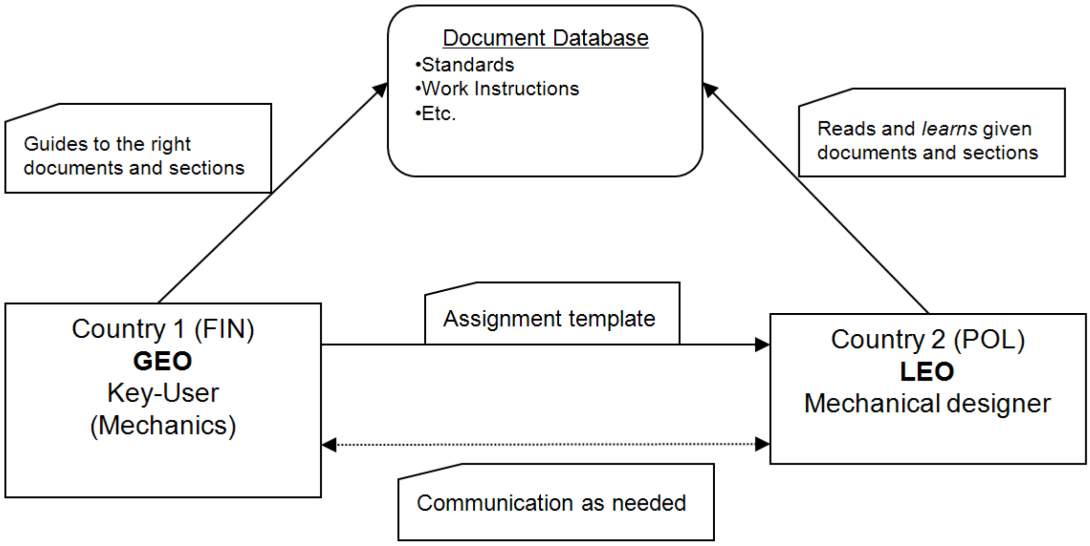

Figure 13 Proposed interaction model for assignments between GEO and LEO

5.4.2. New Interaction model

The communication and task forwarding model is as above. Depending on the size of the LEO, Country 2 has also specialized key-users, but e.g. for Poland there is no need for that at the moment. To minimize the problems introduced in the above section, the model is focused on long-term learning and sustainable relationships.
The key question is how can a person with a different background give accurate tasks and specifications to another person via an electronic medium. If a person writes long and very specific introductions to the other person and includes all the information s/he knows, s/he has done the work already. Thus, giving evermore accurate specifications

cannot be the answer. The answer proposed here is that the task giver should give only knowledge and information which the other person cannot get on his/her own easily and efficiently. In brief : the task is given by a semi-standard one-page (Ward, 2007, p.190) word-document. It contains all the information and knowledge that the LEO designer cannot know. This includes the crucial tacit knowledge that designers must have of the context of the task.

The key-user who gives the task has that knowledge. It can be put to conventional specifications as numbers, but this does not transfer the knowledge. This ends up in a situation where the LEO designer does not understand wh*y* things are done like that and specifications are understood differently because there is no real knowledge. This, furthermore, leads to a design result which requires a lot of iteration and to time wasted by both of the designers with still no real learning.

The task template is the key component in this new model. Let us look at that now in detail.

5.4.2.1 Task template

When the GEO key-user wants to give a task to the LEO, s/he first fills in the task template. The task template is a one page document (Ward, 2007, p.190) which has the needed information that allows the LEO designer to learn and do the task. It contains fields about:

- Task name
- Task description
    - Including the main specifications. Always as numbers or clear guidelines.
- Standards and work instructions
    - As specific a section of the standard or the work instruction as possible
- Good to know: knowledge
- Parts and assemblies which will be influenced or should be taken notice of
- Customer contacts or other interest groups
- Deadline date/week
- Support person/s
- For R&D cases: a risk assessment

When the key-user in Country 1 has completed the task template, s/he can send it to other persons in the organization who have knowledge or information about the task. They, in turn, should add text to the document. Especially important is the good-to-know field which is designed to capture the tacit knowledge of the designers. The good-to-know field should answer the question: What things should the key-user or others give to the LEO designer in order for her/him to complete the task well?

Also very important are the standards and work instructions. They achieve three things: *standardizing* the design process for best practices around LEOs and *teaching and assisting* LEO designers in designing the Cargotec products. At the same time, GEO designers will look at the standards and work instructions and maybe standardize their own design also. The point would be that the key-user would know which standards and work instruction *sections* to give to LEO designer. I emphasize sections because, e.g. the crane standards are very extensive. Therefore it is forbidden to give the whole standard as “help”. The key-user should know which specific sections to apply to a task and attach those as a link to the task template. This transfers true knowledge as “the teacher” gives sections to read, from which the LEO designer can *learn* the background and context.

5.4.3. Implications and risks

When asked about the above model, many interviewees expressed their worry about some people not having the ability or interest to transfer knowledge in this way. Some may have deep fears of losing their jobs if they give their unique tacit knowledge away. They teach the other person to be their successor. This has to be tackled with clear communication from the management, stating that this is not the case. A global company requires shared knowledge to operate, grow and innovate.

A summary of the proposed solutions within the context of the framework, tools and the theoretical model can be found at the end of Chapter 5.

5.5. Practical recommendations for Cargotec to improve integration

Although the processes and the tools developed in this thesis are a step in the direction of better capturing of knowledge and markets for global operations, it is just the beginning. While researching and talking with different people in different functions across Cargotec, it was found that much more can be done to improve the global capacity. The most important recommendations are found in the table 8.

Table 8 Found matters that could improve future integration within Cargotec

Manufacturability	One of the key things contributing to quality problems in global manufacturing is that design and manufacturing are nowadays separated. People say that the old times were better because an engineer could just walk to the manufacturing facility and assemble and confirm a problem or ask advice from the welders, assemblers and production managers. This is confirmed also by Armstrong and Cole (2002, p. 172-173). One example of this are the rails on top of the beams on a RTG which are "impossible to weld", according to the manager of MAU Tampere. To improve the situation, Cargotec has to develop new, innovative ways of linking the manufacturing knowledge to engineering, especially mechanical design. This can be done in numerous ways, but some research has to be done to find the best solution to the problem. There is no better time to start this than now because almost all the manufacturing is already done off engineering sites.
3D-model management from need-to-know basis to a reverse classification	Cargotec's present system of classifying every 3D-model as classified for everybody except GEO designers is outdated and harmful to the design process. They need to define a process which automatically makes all 3D-models globally free when they are released from the R&D department to customer projects. However, there has to be a way also to classify some of the models in special cases to be only locally free. One of these cases could be if R&D is field testing new technology for a customer.
PDF software	Cargotec needs to add PDF marking tools to all work stations. Designers can then mark PDF drawings with arrows, text and boxes to communicate effectively across email.
Use of shared Catia models	Catia has an inbuilt feature that allows designers to model and modify *one shared model*. Use of this has to be marketed more and insisted on to LEOs and GEO designers.
Video capability	As the Veinott, Olson, Olson and Fu (1999, p. 307) study suggested, for non-native language pairs, e.g. a Finn and a Pole, video helps a great deal in explaining complex matters to the other party.
Standardization of design work	YC customer project engineering and R&D should start developing tradeoff curves to share design knowledge and to make design decisions based on data.
Training mental models	Because of global companies' imperative to understand and respect different cultures and ways of thinking, it is crucial to understand what our own thoughts and behavior are based on. Mental models are a rather simple tool for modeling how our assumptions and history impact our behavior. Teaching this to all employees, especially to those who are constantly in interaction with other cultures, would be beneficial.
Global offshoring design/R&D strategy for Cargotec division's	Cargotec should form and execute a global strategy about what levels and parts of technology, products, applications, services and design work it wants to offshore from global design offices. It should decide what it wants to keep in-house and what it does not. The same goes for outsourcing development to suppliers.

5.6. Summary of the proposed solutions within the context of the framework, tools and the theoretical model

The summary shows that the theoretical model supports the integration framework and its tools. One can also see that the integration framework answers the challenges found from the current situation at Cargotec Tampere and the China design office. It also includes the teachings learnt from MacGregor.

Table 9 Summary of the proposed solutions within the context of the framework, tools and the theoretical model

Theoretical model	Current Problems			Perspective from MacGregor	Proposed Solution
Combined theoretical model	Information Systems and Standards and work instructions	The state of LEO integration	Learning from China Design Office	Learning from MacGregor	Integration framework for offshore design offices
Global design imperatives					
Transparent Strategy/goals		On-going work to unify the Cargotec-wide process	No practical strategy communicated for CDO, failed initial execution	Clear vision of how global and distributed design works in practise Long-term view for design partnerships Top managers are committed to the global design operations	Understand the needs of the new office and the timeframe in which the partnership will happen (FW -Survey)
Standardization of design work	Most of the standards are location specific and design instructions are tacit knowledge	No common standards across locations	No common standards across locations	System for common design practises made and developed	Maps the needed common standards which are needed for the LEO and opens up access to the common 3D database. (IP) In the future, a common database for general design knowledge (IP)
Interaction model				Semi-defined way of doing global design CROL process gives a feedback loop for the interaction.	Understanding the LEO's interaction model and processes (CSA) Signed contract (FR-Sharing) Explaining what is the interaction model at Cargotec (IP)
Common tools (same software, file types etc.)	Existing but also software problems and slow network connections	Every tool has to be global and documents in the same system	CDO had no access to the files or models of the Tampere office because of the fear of intellectual property infringements Software and communication tools were good	They verify the same tools by doing a pilot design case before signing a contract	Checking that the LEO has the same tools and resources that the GEO has (CSA) Giving and checking that the same tools are in place at LEO (IP) The pilot task tests the common tools in practise (FR-Verification)

(Continued from the previous page)

Combined theoretical model	Information Systems and Standards and work instructions	The state of LEO integration	Learning from China Design Office	Learning from MacGregor	Integration framework for offshore design offices
GEO and LEO (local context)					
Culture			Most employees move to higher paying jobs very easily Generally the intercultural problems lessen with time Intercultural awareness training needed	Trust in the China office is very low	Mapping the risks of different locations (Risk assessment) Formal intercultural training (IP)
Technical know- how and know- why	A lot of local legacy standards in use at Tampere	A lot of local tacit knowledge at Tampere	The initial knowledge of the designers was lower than expected The transfer of tacit knowledge was non-existent or very slow	Sharing of technical knowledge only local. Common global standards Big gaps in knowledge outside Finland	Understanding the skills and the experience of individual designers (CSA) Integration package tries to level the resources and the skills of the LEO (IP)
Management style			The Finnish managers first had to teach the Chinese managers, who then taught Chinese designers Attention to special things, e.g. mistake-handling		Communicating in "the Cargotec way" for many practical things for the managers of the LEO (IP)
Intellectual property rights			Fear of intellectual property infringement slowed the design work considerably because the 3D-models were not accessible	Big problems of protecting their 3D-models and design knowledge. This is true especially in the case of China.	Mapping of counter measures from the LEO (CSA) Communicating the importance of intellectual property management (IP)
Principles of cross unit co-operation					
Communication	Tools for easy global communication exist		No authority to handle disputes between offices but generally supportive and warm relations Face-to-face meetings are very important	Information is going almost only from top to bottom LiveMeeting praised	Selection of the integration chief (FR-Sharing) Interaction model guides the communication (IP) Formal feedback process at the end of the pilot project (FR-Verification)

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Combined theoretical model	Information Systems and Standards and work instructions	The state of LEO integration	Learning from China Design Office	Learning from MacGregor	Integration framework for offshore design offices
Team Spirit			Face-to-Face meetings support the creation of team spirit	Rarely designers meet but they have formal feedback processes (CROL)	Budgeted face-to-face meetings and rotation creates team spirit (IP)
Learning from each other	Cargotec does not have a shared design database, so learning is very distributed and not managed		Two engineer managers had to be sent to CDO to transfer knowledge		The integration package gives as much information to the LEO as possible (IP) The proposed interaction model should create true learning in both ways (IP)
Respect					Communicating the values of Cargotec and when designers get training for other cultures, mutual respect should grow (IP)
Combined theoretical model	Standards and work instructions	The state of LEO integration	Learning from China design office	Learning from MacGregor	Integration framework for offshore design offices
Rewards of successful integration					
Quality Design				Emphasis on design managers	When the process have been gone through, the result from LEO should be quality design
Trust			Trust cumulates with time and builds up relationships and smooths conflicts		Risk assessment before the signing of the contract (FR-Survey) Signed contract (FR-Sharing) Budgeted face-to-face meetings and rotation creates trust (IP)

6. TESTING THE PROPOSALS

Although good feedback was received from the interviewees when presenting the framework and tools, the results had to be tested in a more formal way. For the testing there were two formal test setups. This chapter gives a general idea of the methods and results of the tests.

6.1. Workshop for managers at Cargotec

After the framework and the tools had been developed for three and a half months, there was a workshop for ten middle and senior design and R&D managers. The effective work time for the workshop was three hours.

The participants were divided into predetermined groups of three or four people. The current researcher, the customer project manager and one person from HR acted as chairpersons in three individual worktables. Worktables were stations for development containing one aspect of the framework and its tools. The three groups had 30 minutes for one worktable and then moved to the next.
The workshop groups were as follows:

1. Group: the framework, risk analysis and the integration package
2. Group: current state analysis and role template
3. Access rights – document and manuals and instructions list

From the workshop it became very clear that the framework and its tools are valid for use at Cargotec. In addition, the managers suggested many good improvements. In total, 64 new suggestions were received. Furthermore, the participants also made 6 wider development suggestions for the whole design operation. The large-scale development suggestions are, however, not within the scope of this thesis. Most of them were outside because they were simply projects too vast to start or they were not important in terms of the focus of the thesis. They will be considered later. The most important improvements are summarized in Table 10.

Table 10 List of the most important improvements found at the workshop for managers.

Within the scope of the thesis	Outside the scope of the thesis
CSA: Add: 3D-modeling skills, drawing skills, writing/reporting skills, documentation skills	CSA: Add: Personal skills, personality test
CSA: Modify: Change Catia to Modeling software, Auric to PDM system and add lists of usual brands	The Framework: How the responsibilities and task sharing will be handled. Who makes the concept design?
Authority Rights: Add: To ease the authority right designation, virtual roles could be made. E.g. R&D Mechanics, PMO Mechanics, etc.	Authority Rights: Add: Tampere network disc mapping (what are the different discs? / map all of them), different names for different users -> absolute paths to discs.
Authority Rights: Modify: 4 weeks is too long for the manager to fill an access right request. One week maximum.	Authority Rights: Add: other location's network discs
Authority Rights: Add a field: training needed, a box next to an item (e.g. software)	Manuals and instructions: Add: LEO personnel’s training packages according to roles
Manuals and instructions: Add: Traveling instructions	
Risk Assessment: Add: A lot of different risks	

According to my own experience and discussions with the other worktable chairpersons, the topics and tools brought up a lot of discussion and even arguments. One clear convergence happened in terms of the agreement to use design roles as a basis for evaluating LEO designers and also for training and giving access rights.

Evidence for the suitability of the developed framework and tools for practical use are visible when the ten managers were asked in the beginning what was, in their opinion, the most pressing challenge in integrating offshore design offices. After the workshops we discussed whether the framework and the tools answer the challenges. The result was that out of ten challenges, 8 directly, 1 partially and 1 not at all, were answered by the framework and tools. The last one, not at all, was about how the projects done in a LEO should be defined according to its strategic position in terms of technology and general strategy. That was, in effect, outside the scope of the thesis.

The workshop acted as a development meeting, but also functioned as a training platform resulting in a good level of engagement from the managers toward the new approach to new design offices within Cargotec.

6.2. Testing the proposals in Cargotec Engineering India

The suggestions from the management workshop were incorporated to the framework and tools. After that the tools were tested at Cargotec Engineering India (CEI). Because the framework and the tools were developed to be used for a new design office and CEI had already been working for three years before the testing, the parts of the test that could not have been applied were left out. The main focus of the test was to verify whether the tools were easy to use and easy to understand.

The CEI was contacted and told that the managers from their Mechanics and Electrical departments are responsible for filling out the documents in the tools. They were told that the tools were in development and all improvement ideas were welcome. First, the current researcher gave the two managers a half an hour presentation over the Internet and the current state analysis tool was given. They had to independently fill it and attach all the role documents from their available designers. Second, the current researcher and the CEI managers discussed the results over the Internet using LiveMeeting. After that the integration package was sent to CEI and they similarly filled it out along with the manuals and instructions list in two days. Then the current researcher and the CEI managers discussed the results in similar way than with the CSA.

All the problems in the tools were recorded and corrected. Suggested improvements were later implemented. Table 11 shows the problems and suggestions in a summary.

Table 11 List of the problems and suggestions found by the CEI

Current State Analysis	Integration Package
Confusing piece of text in the rows 96-99 accidently left from the previous version	Add to the last section, The delivery of standards, “similar standard” column.
The question about the client list was confusingly set	
Add text “If the item is not applicable, insert N/A”.	
Role documents	
Confusion about what competences to fill with the standard section	

More important than the detail errors and misunderstandings with the tools was that the test was also to assess the evaluation process. Because CEI is not a new office, the time used to complete the IP at CEI cannot be said to indicate the time needed for a completely new office to execute the process. According to the two managers at CEI, it took 1 hour for them to fill out the CSA and ten hour for ten role documents. So to sum, it takes approximately two working days to complete the evaluation phase of the integration framework for a LEO.

The opinion of the two managers at CEI was that the tools were clear and understandable. From the testing it was evident that they did not require significant help filling out the documents and they also did not do any significant mistakes while doing so. More importantly, when asked, the managers said that they could see the value of the tools in evaluation and setting joint design practices. The questions were regarded to be relevant to the evaluation of the design operations. These statements are also apparent in Table 11 because the suggested corrections and found mistakes provided only small changes to the tools. From this can be concluded that the tools are ready to be implemented.

7. DISCUSSION

7.1. Results from the research and the research questions

In this Master's thesis a framework for integrating offshore design offices to a main design office has been developed. The problems were that without a well-developed framework the integration is not achieved to the fullest, and considerable amount of time is wasted. The goal was that the two offices, GEO (Global Engineering Office) and LEO (Local Engineering Office), would experience efficient and effective integration so that their cooperation would be close to ideal as fast as possible.

The research problem was to develop an integration model and tools for offshore design offices. The research questions were 1. What kind of integration model is the most efficient for Cargotec in the short and long-term? 2. What kind of skills, knowledge or processes are needed from the local design offices to be capable of doing design work for the global design office? 3. What kind of resources, help or material does the local design office need in order to integrate faster and better to global design operations? The answer to the research problem and questions can be looked at from two perspectives: theoretical and practical.

From the theoretical perspective, the research problem and the first research question were approached by developing the combined theoretical model of efficient integration from the literature of global engineering networks, virtual teams and supplier integration. A combined theoretical model had to be created because none of the three models from these areas was satisfactory. The model of global engineering networks, developed by Karandikar and Nidamarthi (2005), is one the main sources and an excellent source on the subject, but it lacks practicality and specifics. The model of virtual teams is more a collection of topics than a real model. Therefore it cannot be used to build an integration model. On the other hand, it provides useful data, ideas and direction regarding what things should be considered when talking about global teams and how to bring them together. The main source for the model came from Powell, Piccoli and Ives (2004), whose article is an excellent one on the virtual team subject. The topics found after reading 20 articles about supply integration into new product development, shed some light on the actual integration process from an extensively researched field. The 20 articles basically verified the two previous models, but the perspective of the supply side of industrial processes was not enough on its own.

From the empirical perspective the research problem and questions were approached by developing an integration framework and assisting tools for practical work. The framework was based on the combined theoretical model and interviews with more than 15 different customer project designers, specialists and managers. The framework deals with the research problem and the first research question effectively. The framework consists of three phases: survey, sharing and verification. See Table 11 (next page) for a summary of the research questions and developed solutions.

The survey phase defines the need for a new design office, maps and evaluates the capabilities of the prospective design office, and evaluates the offshoring risks. This provides an answer to the second research question. A tool, called current state analysis (CSA) was developed to guide the evaluation and mapping process. CSA evaluates the prospective LEO's software capabilities and maps its core processes. It also evaluates the capabilities of the LEO's individual designers according to their use of software standards, references and language skills. After the CSA, there is a formal risk assessment enquiry into the LEO's situation.

The sharing phase of the integration framework defines and shares all the material and other resources of the GEO which the new design office will need to get to the same level as the main design office regarding software, network, skills, material and product knowledge. A tool was developed for assuring that all the necessary material is mapped and given to the LEO. This tool deals with the last research question. I call this tool the Integration Package (IP). The IP is an Excel-document which lists all the different management documents, software, access rights, manuals and other instructions and standards that the LEO will need to be able to work efficiently and effectively with the GEO right from the start of their relationship.

The last phase, verification, is meant to verify the results of the sharing phase by giving the new design office a pilot task which tests the new office's systems, knowledge and communication. After the pilot task there is a formal feedback event to smooth out the roughest edges of the relationship.

Table 11 Summary of the integration framework related to the research questions.

Research Question	Developed solution
What kind of integration model is the most efficient for Cargotec in the short and long-term?	The Integration Framework: 1. Survey phase a. Needs mapping b. Current state analysis -tool c. Risk assessment 2. Sharing phase a. Nominate integration chief b. Implement and check the integration package -tool 3. Verification phase a. Pilot task b. Feedback
What kinds of skills, knowledge or processes are needed from the local design offices to be capable of doing design work for the global design office?	Current state analysis –tool: - Same software and other tools - Network capabilities - Hardware resources up-to-date - Mapping of the design experience and the processes of the new design office - Mapping of capabilities of individual designers
What kind of resources, help or material does the local design office need in order to integrate faster and better to the global design operations?	Integration package -tool: resources given and checked for the new office - Management documents - Authority and access rights - 3D-model management - Software - Manuals and instructions - Delivery of standards

The testing of the framework and its tools showed that they were a good start in solving the research problem. The workshop for Cargotec design managers showed that the ideas of the tools can be used in practice and all of the managers committed themselves to the use of the tools. The in-action testing of the evaluation tools in the Indian design office showed that the tools were easy to use and achieved their purpose as showing the current state of the particular design office. Naturally, the framework and the tools have to be developed continuously based on gained experience.

7.2. Contributions of the thesis to prior research

I believe that the framework and its tools are an improvement on the only model that has been published about the integration of global design offices by Karandikar and Nidamarthi (2005) and improved by Karandikar (2009).

A major theoretical improvement comes from extending the combined theoretical model and framework to a more detailed level than any of the articles that were read about global engineering networks, virtual teams and supplier integration literature. This was possible because all of these three areas of research were used together. All three areas have different perspectives on the needs and success factors of how integration should be done. When combined, they give a well-rounded but deep view of the issues involved in integrating offshore design offices. Karandikar and Nidamarthi's (2005) model is based on three case studies, and in my view lacks much of the practical specificities needed for actual guidance on how to carry out integration in the design context. In my theoretical model and framework I tried to examine more specific aspects of design office integration.

A practical improvement is that not only a detailed framework and a base for a process has been presented, but also concrete tools that support the abstract framework. The tools can be, with a little extra work, adapted to other products and engineering areas. However, when applying the results it has to be remembered that qualitative constructive research methods were used for this thesis. Therefore, the results cannot be extensively generalized.

Although I criticize Karandikar and Nidamarthi's (2005) model, it is clear that I have used their model as a base for my own and that it was very well suited. Powell, Piccoli and Ives' (2004) article is also strongly present but acts more as supportive evidence. A specific point about integrating design offices that I disagree with is that the host company should encourage good communication with monetary rewards as one company in Suchan and Hayzak's (2001, p.179) article suggests. Pink (2009) has showed clear evidence against this working in the long run. It is clear that good communication should be encouraged and supported, but this should be done with face-to-face meetings (e.g. Kirkman et. al, 2004, p.186) and with "water-cooler talk" (e.g. Makumbe, 2008, p.143). On the other hand, the interviews in this thesis support Jarvenpaa (sp) and Leidner's (1999) work strongly. They emphasize the importance of trust between team members. In general, many of the same things found in the literature have been used in the interviews.

Only one article (ironically, Suchan and Hayzak's, (2001) mentioned mental models from system thinking and incorporated other principles from Senge's system thinking or Argyris' double-loop learning. I have tried to take some of the ideas presented by them into the interaction model between design offices. Mental models are an effective way of making people understand their own assumptions and biases which lead behavior in wrong directions. Incorporating system thinking into the integration process would be very beneficial to global and virtual design teams. If designers in industrialized countries perceive the designers in emerging countries as less intelligent people, the danger is that this creates a negative feedback loop which reinforces itself. In addition, system thinking and double-loop learning can improve the major problem of different contexts between GEO and LEO, as I show in my theoretical model. First, managers and designers have to understand that the mental models of the location where they are, will not apply to another location e.g. India. With system thinking and double-loop learning the designers can learn from each other more effectively and truly share knowledge, not just information. In doing so, I believe the contextual gap between offices can be narrowed. Naturally, this will not happen overnight and without costs. On the other hand, this can be started right away if Cargotec adapted the interaction model proposed as a starting point in developing task-giving methodology between offices.

7.3. Practical recommendations

This thesis was essentially done because Cargotec Tampere did not have a model or a defined process for integrating offshore design offices effectively. The developed integration framework and its tools are the first steps to achieve this. The framework and the tools have already been in use in the testing period of the thesis. They received very positive feedback in addition to some good improvement suggestions. In addition to the integration framework, the tools and the interaction model, I would recommend that the designers in GEO and LEO would also be taught the combined theoretical model. The model has the advantage of showing the most important aspects of the integration process. It provides designers with a conceptual model with which they can reflect upon their experiences and actions. Especially important in the model is the understanding of the different contexts of different locations.

More detailed recommendations are focusing on the standardization of design across locations, emphasizing excellent manufacturability and developing an open offshoring strategy for design operations.

For Cargotec as a whole the recommendation would be that first the company should try the framework and the tools extensively for the Yard Cranes product line. After the tools and methods are developed in practice, the same tools and methods could be transferred with modifications to other product lines.

I would be very happy to see the interaction model adapted and developed at Cargotec. I see it as a first step towards a learning company. This is badly needed because of its world-wide operations. In a rapidly changing world, knowledge transfer across locations and departments is crucial in order to stay competitive and agile.

For Cargotec to be a learning company, it also has to be open. This is why it is suggested that there would be much fewer restrictions on information sharing - and especially 3D-model sharing - across locations. While doing this thesis I have come to the understanding that possible intellectual property leakages are one of the costs of the cheap design workforce in emerging countries. It can be controlled, but it cannot be prevented 100%. A good way to control it is to offer the designers of the particular location as good working conditions and benefits as possible to keep the present employees satisfied. This includes training, respect and meaningful work assignments.

From a larger perspective, it is probable that modern western companies *need* to offshore their less complex jobs to lower cost countries. With time, the Chinese and Indian companies will learn to be as good as their Western counterparts. Western companies have to be ready for that change. The real question for the competitive landscape is that when Chinese and Indian companies can match the quality of Western companies, will their wage and general price level be the same as in the Western world or is it going to be considerably lower. In other words, when companies in emerging countries have the same quality as Western companies, will their price of the product be near the same level as now?

7.4. Limitations

Naturally, this thesis has limitations. The main limitation thesis is that none of the tools are statistically tested with a large test group of businesses. The only testing field was Cargotec. Therefore, generalization of the results to different industries and companies should be done with respect only to the assumptions that I have presented in this thesis. Furthermore, it has to be emphasized that the framework and the tools are for integrating a design office which is owned by the host company. To use the same framework and tools for an outsourced design office should be done very carefully because the assumptions and the goals of the offices are different. The proposed tools are also only at the starting point of their life-cycle and should be under continuous development. The proposals that are presented in this thesis should be applied only for Cargotec. They were suggested only in the context of Cargotec’s current situation.

7.5. Ideas for further research

Opportunities for further contributions are numerous. In the scientific context the offshored design office integration needs more research. The trend of offshoring white collar work to low cost countries is not going to slow down. There should be more research about how the model of Karandikar and Nidamarthi (2005) and the framework developed in this thesis perform in a broader analysis of companies. Are the items in the model important in practice and what items are missing?

In the practical context, and especially in the Cargotec context, many questions and further specifications are needed. In addition to the proposals in Section 5.5, more general questions arise from the thesis: How should the organization structure be changed in order to support global design operations? Should different departments be made modular and how would this happen? What changes and specifications do the products need in order to support more modular and standardized design? Does Cargotec have enough globally ready leaders who are culturally savvy and understand the local and global contexts? How can critical and new information and knowledge be transferred most cost effectively between different locations?

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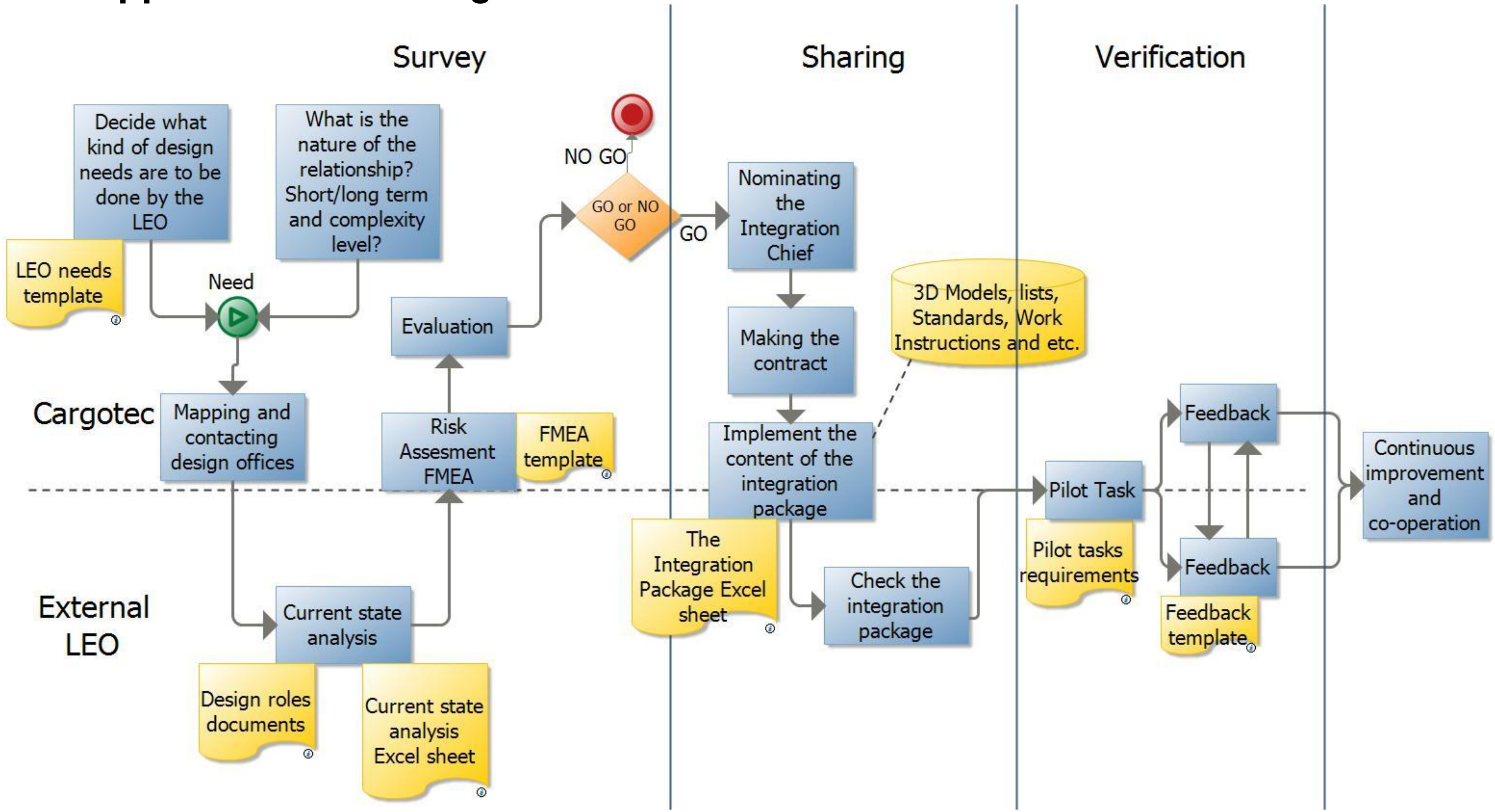
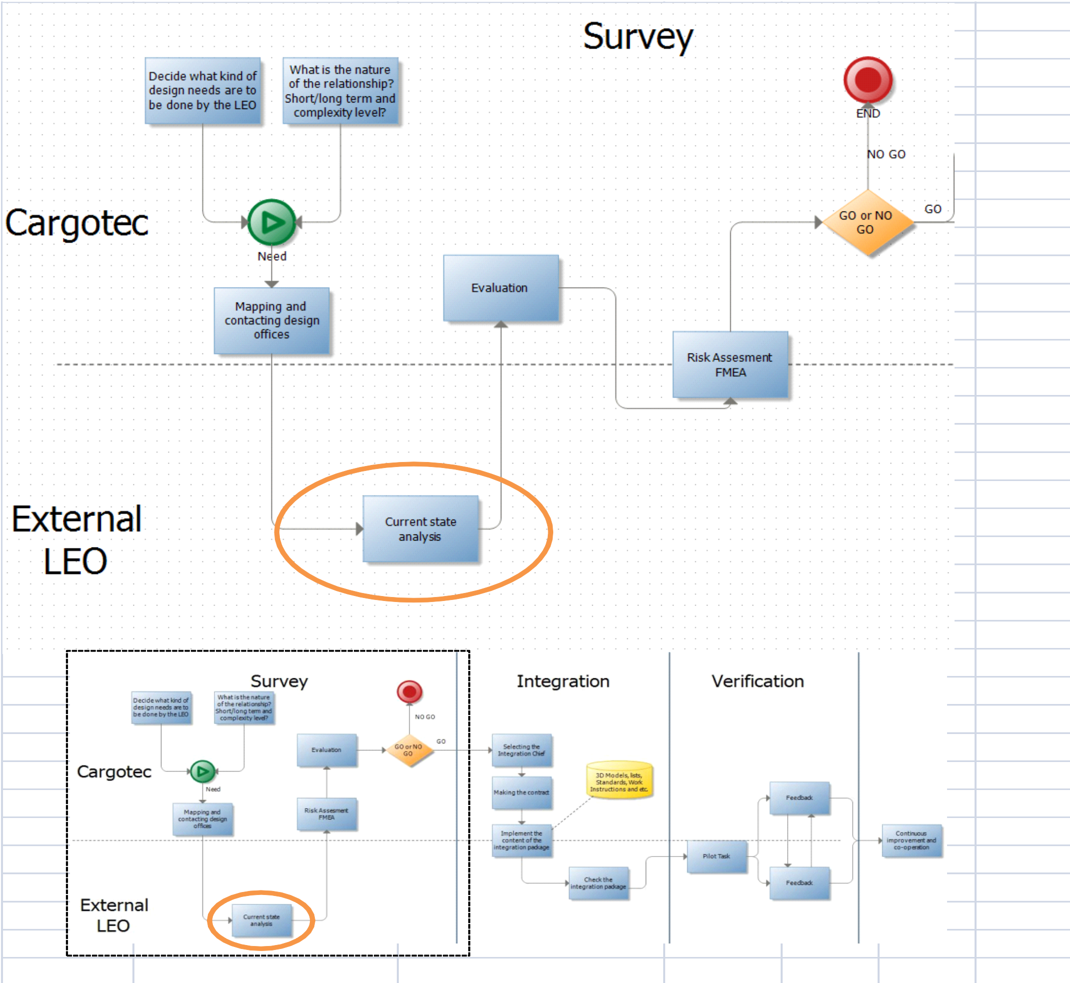
8. APPENDIX

8.1. Appendix 1: The integration framework



8.2. Appendix 2: Current State Analysis



The point of this document is to give guidelines to do a current state analysis for a prospective design office.

In the next pages there are lists which are ment to help asses the new office whatever it can be our partner

The filled chart is an generic case. If your case is different, feel free to delete all the Xs and fill your own.

If some item is not applicable to your case, insert N/A

CURRENT STATE ANALYSIS

	Type:	**Mechanical Design**		
	Product:	RTG		
	Target organization:			
			Number of licenses	
Area	Type	Why?	How many available?	How many needed?
Software (same version as at GEO)				
Basic				
All the software has to be with a genuine license	Auric	Essential		
	Catia	Essential		
	Office Suite	Essential		
	PDF (readind&marking)	Essential		
	Virus scan and firewall	Essential		
	Lotus Notes	Optional (for EOs)		
Communication Tools				
	Phone	Mobile or landline		
	Office Outlook	Calendar and meetings		
	Office Communicator	Text com		
	Office Live Meeting	Talk over IP		
	Video Conference room			
Structural Analysis Tools				
	CATIA Generative Part Structural Analysis (GPS)	Simple strength analysis tool for every day use		
	Catia GAS	Special Strength analys. Tool		
	Catia EST	Special Strength analys. Tool		
	Ansys	Special Strength analys. Tool		
	KRASTA			
	LMS Virtual Lab			
Production Software				
	LN	Load production		
	Baan	Load production		

Area	Type	Why?	Yes	No
Network Capabilities (Can be done?)				
	Over 10 Mbit/s network	To transfer objects		
	VPN capability	Outside access		
	Direct network link to Cargotec network	To Cargotec folders etc.		
Hardware resources			Select	
	Change cycle of designers' computers	≤ 2 Years		
		2< Years ≤3		
		3< Years ≤4		
		4< Years ≤5		
		>5 Years		
	Designers' display size and number	≤20 inch		
		20 < inch ≤23		
		> 24 inch		
		1 display		
		2 or more displays		

Area	Type			Education plan attached
HR practises			Number	Yes?
	How many training days in a year there is for the designers?			
	How is the learned knowledge shared inside the office?			
	How is the designers' mental and physical fitness supported?			

Area	Type	Why?	Do they have it? Yes	No	Top 5 references attached? Yes	Role and depth of the office
Design Experince of the office						
	Crane design	To understand the special aspects of crane design				
	Mobile machine design	**To understand the special aspects of mobile machine design**				
	Project experience	To understand the special aspects of CD projects				
	International project exp.	**To understand the special aspects of intern. Design proj.**				

Area	Type	Why?		
Poject Management				
	Project Management certifications	None		If Yes, specify:
		For some managers		
		For all managers		

Area	Type	Why?	Do they have it? Yes	No	Attached written description Yes	No
Processes						
	Defined design process	To understand them and the integration			☐	☐
	Quality assurance	**Crosschecking, peer reviews, etc.**			☐	☐
	Continuous Improvement process	How the company learns, teaches and improves their performance			☐	☐
	Progress Status Reporting example	**To verify that the status report is clear and proper**			☐	☐
	IT support processes	How the LEO is managing IT support issues			☐	☐
Information Security Mgmt.						
	Clear set of rules and processes	How they protect our knowledge?			☐	☐
	Turnover of personel low	**Turnover can't be high in order to have learning and trust**			☐	☐
	Physical arrangements	E.g restricted areas for Cargotec's designers			☐	☐
	Client list	**Attached list of clients which may be Cargotec's competitors**			☐	☐
	Employee term of notice	What is the term of notice period?			☐	☐

			Do they have it?	
Certifications			Yes	No
	ISO 9001			
	ISO 9004			
Other			Select	
	Location of the Standards	Printed, every designer have their own		
		Printed, a common shelf		
		In a storage room		
		Electronic, everyone can access		
		Electronic, some have access		

Individual Designer's Capabilities (Mechanical Design)

What kind of design knowledge the office has available?

Role	Competence	What	How many are available?	How many are needed
Team Leader MD	Team Management	Possesses broader knowledge		
Mechanical Engineer	Mechanisms	e.g. joints and mech. systems		
	Steel Structures	e.g. RTG columns and beams		
	Access Design	incl. stairs, walkways etc.		
	Equipment Placing and Drawing	e.g. place for antennas or GPS unit		
	Specificating Components (	Knows how to spec different components		
Hydraulic Engineer	Hydraulics - System design	Knows how to design whole hydr. Systems and draw them		
	Hydraulics - Installation design	Knows how to design detail hydr. E.g. how and where to install cylinders		
Calculation engineer	Tech. calc. - Strength			
	Tech. calc. - Stability			
	Tech. calc. - Dynamics			

Descriptions and specifications for each of the roles and competencies can be found from their role documents

8.3.

8.4. Appendix 3: Mechanical Design Roles - Team Leader

Mechanical Design

Role Name: Team Leader

Name of the person:

Shankar Barendran- Design and Drafting (The name has been changed)

Role description: For example, the design of joints and mechanical systems.

Mark here what other competences the person has.

Role	Competences	Description	Mark X for other competences
Team Leader MD	Team Management	Possesses broader knowledge	X
Mechanical Engineer	Mechanisms	e.g. joints and mech. systems	
	Steel Structures	e.g. RTG columns and beams	
	Access Design	incl. stairs, walkways etc.	
	Equipment Placing and Drawing	e.g. place for antennas or GPS unit	
	Specificating Components (incl. Dimensioning)	Knows how to spec different components	
Hydraulic Engineer	Hydraulics - System design	Knows how to design whole hydr. Systems and draw them	
	Hydraulics - Installation design	Knows how to design detail hydr. E.g. how and where to install cylinders	
Calculation engineer	Tech. calc. - Strength		
	Tech. calc. - Stability		
	Tech. calc. - Dynamics		

Design Skills

Area	Type	Level	Mechanical Design Person's skills	Skill req. from Cargotec				
3D modelling software	Basic	<2 Years						
	Mediocre	2≤ Years ≤5						
	Advanced	>5 Years	X					
	Circle/Bold best one	**Catia**	Ideas	**Inventor**	SolidWorks	PRO/ Engineer	Vertex	Other:
Structural analysis software	Basic	0 Years	NA					
	Mediocre	2≤ Years ≤5						
	Advanced	>5 Years						
	Circle/Bold best one	Catia GPS or GAS	Ansys	KRASTA	LMS Virtual	Finsap	Cosmos	Other:
PDM software	Basic	Knows how to navigate						
	Mediocre	Can create new items and modify them	X					
	Advanced	Knows and understands some PDM software in and out						
	Circle/Bold best one	**Auric**	SAP	Other:				
Documen-tation skills	Basic	<2 Years	X					
	Mediocre	2≤ Years ≤5						
	Advanced	>5 Years						
Progress reporting skills	Basic	<2 Years						
	Mediocre	2≤ Years ≤5						
	Advanced	>5 Years	X					

Team Leader Experience

Experience as a project leader	<1 year	
	1-2 years	
	3-5 years	
	>5 years	x
Project Manager certification	NO	Yes?
	If Yes, specify:	
	PMP training (from PMI) attended, Certification under progress.	

Experience about standards according to each selected competence (if the person has been using different but equal standards, attach description of each).

Standard	Description	How many years of active use?	Select the most fitting	Needed by Cargotec	Standard owned by the office		If the person has used *similar* standards: Write here the name of the standard
2006/42/EY	*Machine directive (ENG)*	0 years					-
		1-2 years			Yes		
		3-5 years			No	X	
		>5 years					
FprEN 15011	*Cranes - Bridge and gantry cranes*	0 years					SAEJ958v002
		1-2 years			Yes	X	
		3-5 years			No		
		>5 years					
SFS-EN 13135-2	*Req. for equip. - Part 2 - Non-electrotech. Equipment*	0 years					-
		1-2 years			Yes		
		3-5 years			No	X	
		>5 years					
SFS-EN 12644-1/2	*Information for use and testing - Part1 - Instructions Part2 - Markings*	0 years					-
		1-2 years			Yes		
		3-5 years			No	X	
		>5 years					
SFS-EN-14492-2	*Part 2: Power driven hoists*	0 years					SAEJ820v002
		1-2 years			Yes	X	
		3-5 years			No		
		>5 years					
SFS-EN 12077-2+A1	*Part 2: Limiting and indicating devices.*	0 years					-
		1-2 years			Yes		
		3-5 years			No	X	
		>5 years					
F.E.M. 1001 3 rd Edition	*Rules for the Design of Hoisting Appliances*	0 years					-
		1-2 years			Yes	X	
		3-5 years			No		
		>5 years					

EN ISO-12100-1 & -2	*Safety of machinery. Basic concepts, general principles for design. Part 1: Basic terminology, methodology / Part 2: Technical principles*	0 years 1-2 years 3-5 years >5 years		Yes [ ] No [X]	-
ISO-14122	*Safety of machinery - Permanent means of access to machinery*	0 years 1-2 years 3-5 years >5 years		Yes [ ] No [X]	-
EN 457	*Safety of machinery. Auditory danger signals. General requirements, design and testing*	0 years 1-2 years 3-5 years >5 years		Yes [ ] No [X]	-
EN ISO 14121-1	*Safety of machinery. Risk assessment. Part 1: Principles*	0 years 1-2 years 3-5 years >5 years		Yes [ ] No [X]	-
EN 954-1	*Safety of machinery. Safety-related parts of control systems. Part 1: General principles for design*	0 years 1-2 years 3-5 years >5 years		Yes [ ] No [X]	-

References (one reference can be in more than one place)

Reference	No.	**Customer's name**	**Position/Title**	**Assignment**
Crane design	1.	Kalmar Ship to Shore Cranes	Team Leader	Design layout and Workshop Drawing creation. Maintenance Manual
	2.	Kalmar RTG and ASC	Team Leader	Manufacturing drawing creation
	3.			
	4.			
	5.			
Mobile machine design	1.	Kalmar Lift Trucks and Reach stackers	Team Leader	1.Field failures design modifications. 2.Design Optimisation 3.Manufacturing Drawing creation
	2.	Kalmar Straddle Carrier	Team Leader	Concept design, design modifications and manufacturing drawings
	3.			
	4.			
	5.			
Project design experience	1.	Pier burg, Germany	Sr. Engineer	Automotive Intake Manifold_ Design optimisation and modification
	2.			
	3.			
	4.			
	5.			

International project experience	1.			
	2.			
	3.			
	4.			
	5.			

Language Skills

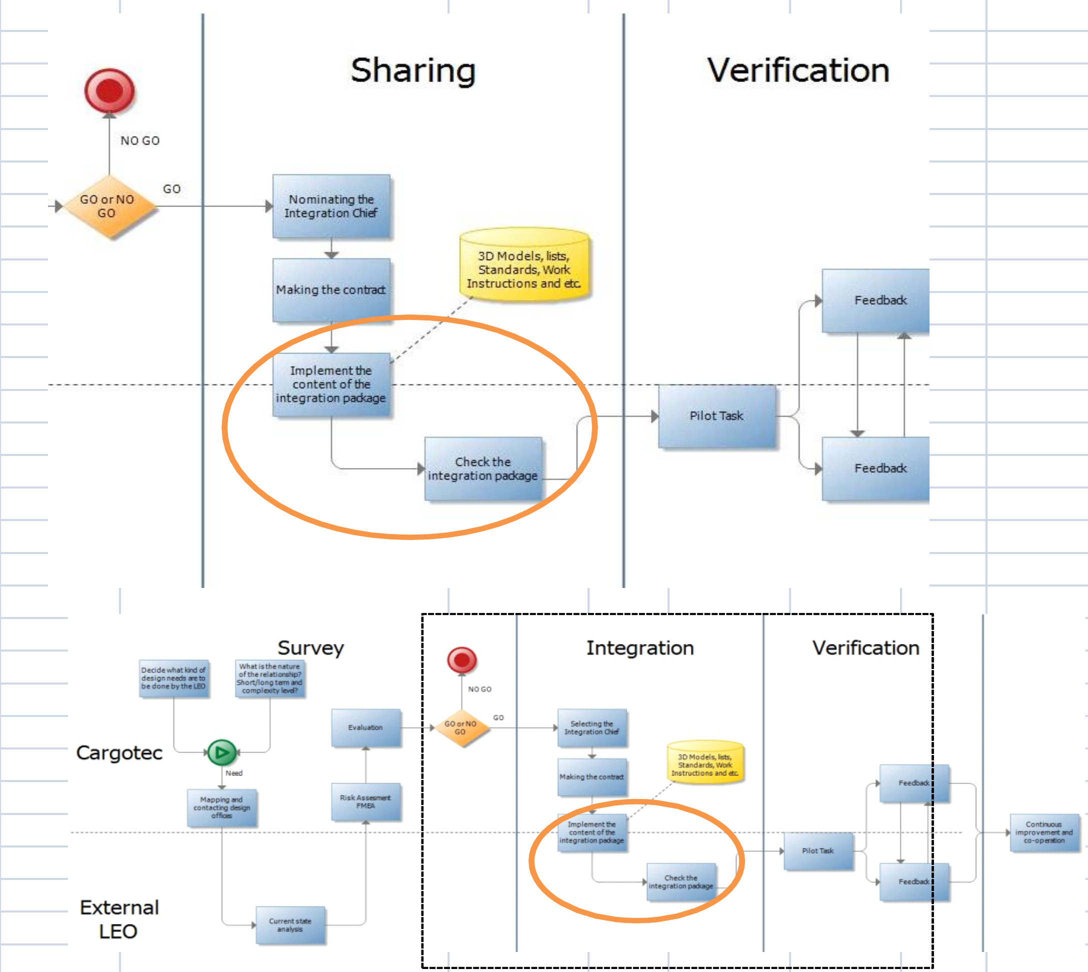
	What level?	Select the most fitting	Needed by Cargotec
According to EU's language standards (C2 is the best)	C2		
	C1	X	
	B2		
	B1		
	A2		
	A1		

The assessment document can be found below.

EU's language assessment tool

Proficient User	C2	Can understand with ease virtually everything heard or read. Can summarise information from different spoken and written sources, reconstructing arguments and accounts in a coherent presentation. Can express him/herself spontaneously, very fluently and precisely, differentiating finer shades of meaning even in more complex situations.
	C1	Can understand a wide range of demanding, longer texts, and recognise implicit meaning. Can express him/herself fluently and spontaneously without much obvious searching for expressions. Can use language flexibly and effectively for social, academic and professional purposes. Can produce clear, well-structured, detailed text on complex subjects, showing controlled use of organisational patterns, connectors and cohesive devices.
Independent User	B2	Can understand the main ideas of complex text on both concrete and abstract topics, including technical discussions in his/her field of specialisation. Can interact with a degree of fluency and spontaneity that makes regular interaction with native speakers quite possible without strain for either party. Can produce clear, detailed text on a wide range of subjects and explain a viewpoint on a topical issue giving the advantages and disadvantages of various options.
	B1	Can understand the main points of clear standard input on familiar matters regularly encountered in work, school, leisure, etc. Can deal with most situations likely to arise whilst travelling in an area where the language is spoken. Can produce simple connected text on topics which are familiar or of personal interest. Can describe experiences and events, dreams, hopes & ambitions and briefly give reasons and explanations for opinions and plans.
Basic User	A2	Can understand sentences and frequently used expressions related to areas of most immediate relevance (e.g. very basic personal and family information, shopping, local geography, employment). Can communicate in simple and routine tasks requiring a simple and direct exchange of information on familiar and routine matters. Can describe in simple terms aspects of his/her background, immediate environment and matters in areas of immediate need.
	A1	Can understand and use familiar everyday expressions and very basic phrases aimed at the satisfaction of needs of a concrete type. Can introduce him/herself and others and can ask and answer questions about personal details such as where he/she lives, people he/she knows and things he/she has. Can interact in a simple way provided the other person talks slowly and clearly and is prepared to help.

8.5. Appendix 4: Integration Package List



The integration package (IP) is meant to give to a new office after a contract has been signed. The point of IP is to the give all the required material so the new office can start to operate efficiently as fast as possible.

If some item is not applicable to your case, insert N/A

The filled chart is an generic case. If your case is different, feel free to delete all the Xs and fill your own.

Type:	**Mechanical Eng.**
Product:	RTG
Target organization:	

Long term means that the relationship is planned to continue more than a couple of assigments.
GEO: Global Design Office (e.g. Tampere)
LEO: Local Design Office (e.g. Cargotec Engineering India)

Who is the Integration Chief: ________________________________

Management

Person who is Responsible for management implementation: ____________________ Deadline:______ ._____.20____

For All	**Confirmed**	**Prerequisite (when the task can be Confirmed)**	**Source**
The responsibilities of different offices are written *and* communicated		From the contract the responsibilities of LEO and GEO are explicitly explained to the both offices	Template: FLOW
The Managers have communicated to the engineers in both offices about the offshoring/outsourcing agenda		GEO and LEO has been given a presentation (or similar) about how the new LEO and GEO relationship will affect to the future of person's jobs	Made new everytime: example FLOW
Education plan have been done for the new office		Plan created by the Education Plan -template according to the gaps found in the Current State Analysis. When the plan is approved,	Template: FLOW
The interaction model has been created and agreed by the new office		Presentation and training to LEO (and GEO) about how the day-to-day task giving and approval process goes	Semi-Standard: example FLOW
Communicate the guidelines for mistake and problem handling (The Cargotec way)		Presentation has been held for the LEO about the desing policies at Cargotec	Made new everytime: example FLOW
Country specific attributes about the generic culture and habits of it given to the both locations about each other		Confirmed when GEO chief engineer has received country training	Made new everytime: example FLOW
Reporting tools have been given		Reporting tools have been checked and trained for LEO and GEO designers	Found: FLOW

For long term only	Confirmed	Prerequisite (when the task can be Confirmed)	Source
Rotation plan have been done for the new office		A schedule and budjet are made about how different designers are going to visit the locations	Made new everytime: example FLOW
Strategy and a roadmap for the new office has been made, discussed and approved		Long term strategy about the future of LEO and GEO has been made and approved	Made new everytime: example FLOW

<u>Rights management and 3D-models</u>

Person who is Responsible for Rights management implementation: ___________________________________

For All	**Confirmed**	**Prerequisite (when the task can be Confirmed)**	**Source**
All the needed access rights are mapped and opened to folders and		See attachment *"Cargotec design access rights"* -document	Found: FLOW

For short term only	**Confirmed**	**Prerequisite (when the task can be Confirmed)**	**Source**
Required 3D models are given to LEO according to their assigments		Because of the short term assigment the LEO is given only the models which it needs. They are mapped and sended to LEO	Instructions and guidelines: FLOW

For long term only	**Confirmed**	**Prerequisite (when the task can be Confirmed)**	**Source**
All basic 3D models are to be given to the new office		LEO can access the globally freed 3D Catia models database/folder (also standard 3D components)	Instructions and guidelines: FLOW

The prerequisitive for all of the sections in this page is that the item has been given or confirmed to be working at LEO

Deadline:______ .______.20____

<u>IT</u>

Person who is Responsible for software implementation: ____

Software

Basic	**Confirmed**	**Source**
Auric		Tieto
Catia		Santahuhta
Office Suite		Tieto
Lotus Notes		Tieto
PDF (reading&marking)		Tieto

Production Software	**Confirmed**	**Source**
LN		?
Baan		?

Communication Tools	**Confirmed**	**Source**
Outlook 2007		Tieto
Communicator		Tieto
Live Meeting		Tieto

Strength Analysis	**Confirmed**	**Source**
CATIA Generative Part Structural Analysis 2 (GPS)		Santahuhta
GAS		Santahuhta
?		Santahuhta

Platforms

Basic	**Confirmed**	**Source**
Flow		Tommi Karpela
Team Sites		TS creator
OPAS		?
LOTUS Notes		Tieto
Kalmar Management System		Tieto

Network Capabilities

Basic	**Confirmed**	**Source**
Over 10 Mbit/s network		N/A
Extranet to Cargotec		Tommi Karpela
VPN capability		Jari Hautamäki

<u>Manuals and instructions</u>

	Confirmed	**Source**
Manuals and Instructions List given to LEO		Flow: www........

The Delivery of standards

*For example: Marks' Standard Handbook for Mechanical Engineers

Person who is Responsible for The Delivery of Standards implementation: ______________________________ Deadline:______ .______.20____

		Access to the standards verified Mark if Yes	Mandatory - Mechanical Design Competences										
			Team Leader	Mechanisms	Steel Structures	Access Design	Equipment Placing and Drawing	Specificating Components	Hydraulics - System design	Hydraulics - Installation design	Tech. calc. - Strength	Tech. calc. - Stability and Dynamics	Tech. calc. - Stability and Dynamics
	Reference guide to Mechanical engineering fundamentals*		x	x	x	x	x	x	x	x	x	x	x
2006/42/EY	Machine Directive		x										
SFS-EN13001-	General principles and requirements				x						x	x	x
FprEN 15011	Cranes - Bridge and gantry cranes		x	x	x			x			x	x	x
SFS-EN 13586	Access					x							
SFS-EN 13557	Controls and control stations							x					
SFS-EN 13135-2	Req. for equip. - Part 2 - Non-electrotech. equipment		x	x				x	x				
SFS-EN 12644-1	Information for use and testing - Part1 - Instructions		x										
SFS-EN 12644-2	Information for use and testing - Part2 - Markings		x										
SFS-EN-14492-2	Part 2: Power driven hoists		x	x				x					
SFS-EN 12385	Steel wire ropes - Safety							x					
SFS-EN 13411	Terminations for steel wire ropes							x					
BS EN 13411-6	Part 6: Asymmetric wedge socket							x					
SFS-EN 12077-2+A1	Part 2: Limiting and indicating devices.		x										

8.6. Appendix 5: Supplier Integration Reference Chart

Refers to the pages 23-24.

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