Lappeenranta University of Technology
School of Industrial Engineering and Management
Supply Chain and Operations Management
Master's Thesis

Mika Nykänen

DEVELOPING CONSTRUCTION SITE OPERATIONS FOR EPC POWER PLANT PROJECTS

01.06.2015 in Lappeenranta

Examiners: Prof. Timo Pirttilä
Supervisors: Prof. Timo Pirttilä
M.Sc. Eija Ollus, Wärtsilä Finland Oy, Project Services Director

ABSTRACT

Author: Mika Nykänen

Title: Developing Construction Site Operations for EPC Power Plant Projects

Year: 2015 **Place:** Lappeenranta

Master's Thesis. Lappeenranta University of Technology. School of Industrial Engineering and Management

69 pages, 5 tables, 10 figures and 2 appendices

Examiner(s): Prof. Timo Pirttilä

Keywords: Project delivery, EPC, turnkey, construction, project management, supply chain, subcontractor, labor control, scheduling, global, site operations

The purpose of this thesis is to find development areas for site operations in power plant construction projects delivered by Wärtsilä. The inspected operations are subcontractor management, site material management and work scheduling. The contractor's role in EPC project is to respond for engineering, procurement, and construction supervision. Geographical and cultural differences brings challenges for finding development areas as Wärtsilä delivers projects world-wide.

Searching for development area is mainly made with survey, which answers were collected from the target company's site personnel. Based on the results, with good planning and preparation various problems would be avoided. An external view for the thesis was collected by an expert interview, which was held to three experienced construction operating executives. Interviewees believed that with the selection of right site personnel and clearly defined areas of responsibility will greatly affect the outcome of the project.

Some of the theory has been collected from areas, which have helped to understand the inspected operations on site. Improving competence knowledge has been important due to the broad scope of work and the author's inexperience of the topic. Also generally effective practices from construction projects has been collected to the theory part. Functionality of general practices have been reflected together with the results of empirically collected data for Wärtsilä's projects. As a result, a model was generated where development proposals and the benefits from new procedures were presented.

TIIVISTELMÄ

Tekijä: Mika Nykänen

Työn nimi: Työmaatoimintojen kehittäminen EPC voimalaitosprojekteille

Vuosi: 2015 **Paikka:** Lappeenranta

Diplomityö. Lappeenrannan teknillinen yliopisto, tuotantotalous.
69 sivua, 5 taulukkoa, 10 kuvaa ja 2 liitettä
Tarkastaja(t): Prof. Timo Pirttilä

Hakusanat: Projektitoimitus, EPC, avaimet käteen, rakentaminen, projektin hallinta, toimitusketju, aliurakoitsija, aikataulutus, globaali, työmaatoiminnot

Työn tarkoituksena on etsiä kehityskohteita Wärtsilän toimittamien voimalaitosprojektien työmaatoiminnoista. Tarkasteltavat toiminnot ovat aliurakoitsijoiden ohjaus, työmaan materiaalinhallinta sekä töiden aikataulutus. Käsiteltävät projektit ovat EPC-projekteja, joissa urakoitsijan rooli on vastata suunnittelusta, hankinnoista sekä rakentamisen valvonnasta. Haasteita kehityskohteiden etsimiselle tuovat maantieteelliset ja kulttuuriset erot, sillä Wärtsilä toimittaa voimalaitoksia maailman laajuisesti.

Kehityskohteiden etsiminen on pääosin tehty tutkimuskyselyllä, johon vastauksia kerättiin kohdeyrityksen työmaahenkilöstöltä. Tulosten perusteella hyvällä suunnittelulla ja valmistautumisella vältytään monelta ongelmalta. Ulkopuolista näkemystä työhön saatiin asiantuntija haastattelulla, johon ottivat osaa kolme kokenutta rakennusalalla toimivaa johtajaa. Haastateltavien mielestä työmaahenkilöstön valinnalla ja vastuualueilla vaikutetaan suuresti projektin lopputulokseen.

Teoriaosaan on kerätty aihealueita, jotka ovat auttaneet hahmottamaan toimintaa työmaalla tarkasteltavissa toiminnoissa. Työn laajuuden ja tekijälle lähes tuntemattoman aiheen vuoksi aihealueeseen liittyvän osaamisen kehittäminen on ollut tärkeää. Teoriaosuuteen on pyritty keräämään myös yleisesti toimivia käytäntöjä rakennusprojekteista. Käytäntöjen toimivuutta Wärtsilän projekteihin on pohdittu työn tuloksissa yhdessä empiirisesti kerätyn tiedon kanssa. Työn tuloksena kehitettiin malli, jossa kehitysehdotuksia ja niiden hyötyjä on esitelty.

ACKNOWLEDGEMENTS

It has been a long and heavy journey. I do hope my thoughts are now unraveled to this paper. The subject of this thesis really put me out of my comfort zone, but that isn't the place to stay when the aim is on the road of success and progress. It really feels good as the company at issue wants to continue this research. It feels still better that I have an opportunity to be involved in it.

I sincerely would like to thank my supervisors for this thesis, Professor Timo Pirttilä for practical advices and Eija Ollus for giving guidelines from company's perspective. I also like to thank all the attendees of the survey and the interview, your role were critical on completing this thesis.

My thanks goes to all the close relatives and friends too who gave their support. I would like especially thank my partner Johanna, who encouraged me when the progress was not roses.

Lappeenranta, June 2015

Mika Nykänen

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND EXPLANATIONS

CE	–	Concurrent Engineering
CPM	–	Critical Path Method
CSFs	–	Critical Success Factors
EPC	–	Engineering, Procurement and Construction
IPP	–	Independent Power Producer
LOB	–	The Line-of-Balance
SCM	–	Supply Chain Management

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Background for the Project

This master's thesis is made for developing construction site operations for Wärtsilä Power Plant's projects. Referring to the company will be used only Wärtsilä from now on in this thesis. This work is focused especially on engineering, procurement and construction projects (EPC). Special characteristics regarding project types will be explained further.

Targets for development at site are in following three operations:

1. Subcontractor management
2. Material handling at site
3. Scheduling

Wärtsilä is using commonly inexperienced subcontractors in projects abroad. Experienced and large subcontracting companies are often not available at all in destination country or some of the larger subcontractors are not interested in Wärtsilä's relatively small projects or they are not profitable to use. Wärtsilä will end up often to take more control from subcontractor than is reputed in contracts due to inexperience and lack of capabilities. For subcontractor management the target will be how to manage an incapable subcontractor and how to steer clear of the foregoing situation. Best practices will be looked for by inspecting contract planning and work supervising with subcontractor. In material handling material flows at site will be inspected. Also finding restrictions that have effect on material handling will be included on studies. In scheduling focus will be in work planning at site and progress reporting with subcontractor.

Construction supply chain management (SCM) has major impact on site operations as these three targets for development includes partly or entirely in construction site's supply chain. Supply chain in Wärtsilä's power plant projects is mainly defined only for material. Supply chain can be defined also for labor and equipment,

but those are under the contract between main contractor (Wärtsilä) and subcontractor. Therefore surveying through the entire supply chain is important in this thesis.

Developing site operations for power plant projects belongs to a construction support functions which development has strategic importance for the company. This is the main reason for initiating this thesis. There are no former studies in this topic in the company. This topic will start a new trend for development. Further studies are very important as the company wants to continue the studies.

1.2 Research problems and objectives

Basis of problem is a lack of planning in site operations. Orderliness from start of the project to an end will gain benefits throughout the whole project. This thesis will answer the problem by introducing guidelines for site operations to be followed from the beginning. Introducing guidelines is the first objective. The second objective is to implicate pros and cons in the guidelines.

Answering to these objectives will be done by following research questions:

1. Which matters effect on planning site operations in EPC projects?
2. How these matters could be improved?

1.3 Research methods

Implementation of this thesis has started from identifying the problem. The problem solving was made in three phases. Answers for the problem were looked in literature in first phase. In second phase interview and survey were given and answers were collected to a data. The data from survey and interview was examined and compared with literature and feedback from company's thesis director in third phase.

The survey was made for receiving information from employees of Wärtsilä. The questions in survey were determined to point out potential problems and to receive solutions. Difficulties in forming the questions were related to the scale of questions as the target group consists of employees with substantial differences in level of expertise. The basis for the survey were planned from the literature definition of survey. The intended form for survey can be found in appendix 1. The survey data is analysed in chapter 4 Analyzing results and outcomes from survey.

A survey is one of the most widespread form to obtain research data, which describes the perceptions, opinions and attitudes of the large-scale groups. A survey is used not only to general mapping, but as well as a pilot study for further research. One aspect of the survey can be considered as a possibility to give protection of privacy. (Anttila. 1998)

The basic principles of the survey are the following factors:

1. A systematic approach:
   - Careful planning that the phenomenon will be sufficiently covered.
2. Representativeness:
   - The target group is selected to look out for scientific representativeness.
3. Objectivity:
   - The data is collected as resistant to consideration and as precise as possible.
4. Quantitativeness:
   - The inquiry produces the kind of data that could be expressed in numeric form. (Ibid. 1998)

The surveys are best suited for different situations, practices and conditions, as well as mapping comparisons. The survey is relatively economical way to obtain information about a large number of people. In the gathering of the survey data the basic assumption is that the defendants are honest and that the answers provide accurate

and reliable information. The problem is that not all respondents may not want or be bothered to answer the survey. The representativeness of the answers is questionable if some group with same kind of backgrounds will leave the survey unanswered. (Anttila. 1998)

Usually the survey is done by the intended form for the purpose and it contains a certain number of questions. The number of questions must be examined by means of pre-testing of the form. The amount depends on the target group level of expertise, training, motivation for answering etc. (Ibid. 1998)

As the survey gives information only in Wärtsilä's projects and internal employee's some external perspective is also desired. Interview were hold for three experts who have substantial expertise from same kind of industry. The interview was made in group and the preparation started with looking out for the literature from group interviewing and elite interviewing. The agenda for the interview can be found on appendix 2.

The group interviewing is intended to create a common situation between the attendants. Characteristically, it differs individually from the interviews. The aim is to obtain information on how the subjects understand things, what kind of experience they have. The group interview is often used, if the defendants have a common workplace or learning experiences. (Ibid. 1998)

Members of the group itself will determine what things within the body of the interview will be raised and the manner in which they are processed. A well organized group interview participants will have the opportunity to listen to other discussion and get ricochets your own thoughts. The group interview may generate a new things out due to group dynamics. (Ibid. 1998)

Elite interviewing is a special case, in which the interviewees are specially selected. They are powerful, well-trained and recognized experts in their field, representing

one of the organization or institution. They have been selected to explore the phenomenon of mind. (Anttila. 1998)

Purpose of the interview is to gather the specialized knowledge in their possession. On account of their position, they have the opportunity to provide information of a phenomenon on the broad issues, organizations, historical development, the future orientations etc. In particular, they know the technical, legal, financial and administrative issues and are able to quickly and extensively to understand the expert territory. The interviewer must also be well and thoroughly equipped and watch out for to be talked over. (Ibid. 1998)

1.4 Company presentation

Wärtsilä Oyj Abp is a global leader in complete lifecycle power solutions for the marine and energy markets. At 2014 it employed 17 700 persons and gained annual revenue of 4.8 billion euros. Its business functions are divided to Power Plants, Ship Power and Services.

Power Plants delivers gas or oil driven combustion engine power plants for flexible power production. Sizes varies from 10 – 600 megawatts. At 2014 Wärtsilä had delivered almost 5000 power plants to 170 countries. Power Plants delivers also LNG-terminals and -supply systems. Most important customer segments are electric utilities, independent power producers (IPP) and industry clients. Electric utilities provides electricity to households and IPPs are investors and sell electricity to the power grid. Industry clients are commonly in mining, cement, oil or gas business which demand for electricity is high and they invest to own power production. (Wärtsilä Oyj Abp, vuosikertomus. 2014)

1.5 EPC Projects

Construction activities are often carried out within boundaries of a project. Projects are typically one-of-a-kind and defined by collaboration and learning across performing the activities. (Eriksson & Pesämaa. 2013, p. 39) Investment and delivery

projects are common in construction industry. The product suppliers (contractor) are delivering projects to customer. The customer is investing to a project and to its outcome, a final product. Contractor focuses on value creation for customer which will be paid as equivalent amount in currency. Contractor focuses also in its own efficiency as it will directly effect to the profit. Customer focuses negotiating and drawing up the most beneficial contracts and supervises the delivery to maintain its needed schedule. Figure 4 illustrates the relation between contractor and customer. (Artto et al. 2006, p. 20-22)

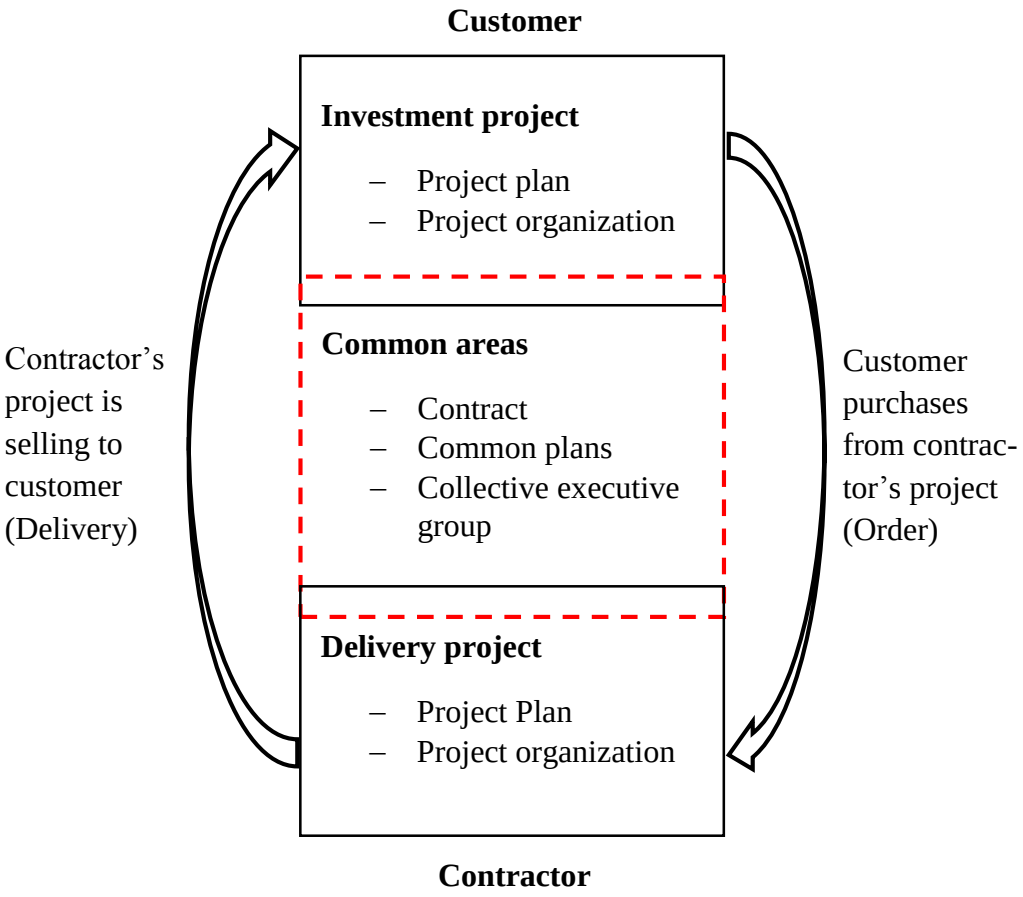

Figure 4. Investment and delivery projects. Modified. (Artto et al. 2006, p. 21)

Engineering, procurement and constructing (EPC) projects are type of project management contracting. They are also called turnkey –projects, which means delivering a solution ready for use. (Haapio & Sipilä. 2013, p. 234–235) Special characteristics of an EPC project are defined as follows by Pillai et al. (2010, p. 6): "In

defining EPC, the key differentiator from other types of project management contracts is not that it is a scope of work, not a form of contract, and requires a single responsibility. Normally a construction contractor taking on an EPC contract assumes responsibility including financial responsibility which brings an element of commercial risk which must be carefully considered."

Figure 5 demonstrates the phases of EPC process. Each phase is determined by actions where contractor's focus should be during the life cycle of the project. The amount of client's involvement in earlier phases could be used as a leverage if disorders appears in execution phase. (Baram. 2005, p. 05.4)

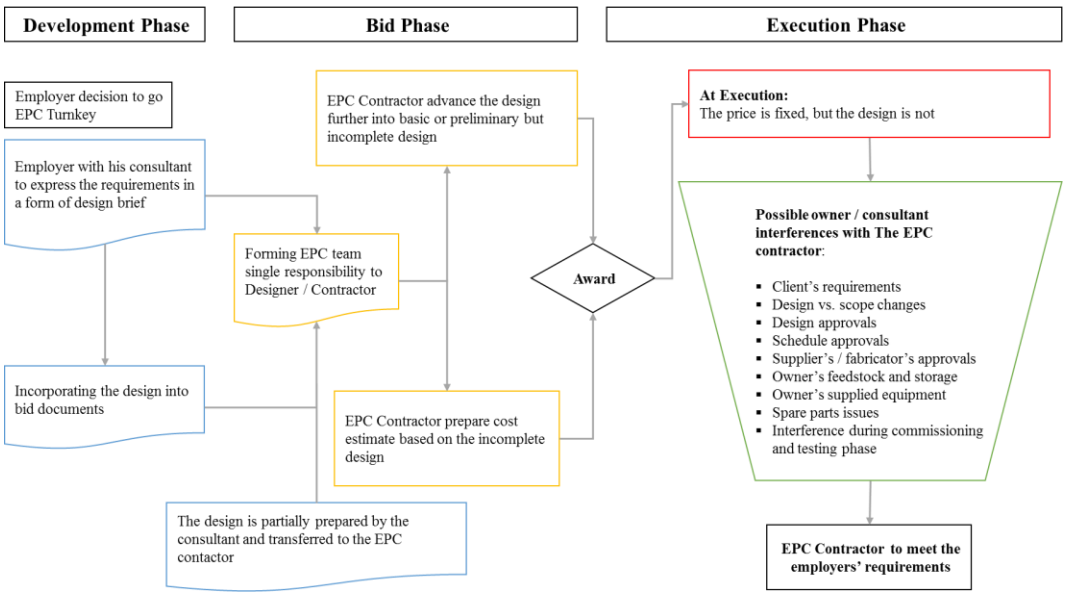

Figure 5. The EPC Process and potential interferences between EPC Contractor and Client / Consultants. Modified. (Baram. 2005, p. 05.4)

1.6 Research structure and limitations

The research structure is explained in figure 1. Chapter 1 focuses on basics introduction to the topic. Chapters 2 - 3 consists of literature review with relation to the topic and explanation of theories involved. Chapters 4 - 6 gathers the empiric data and analyzes it.

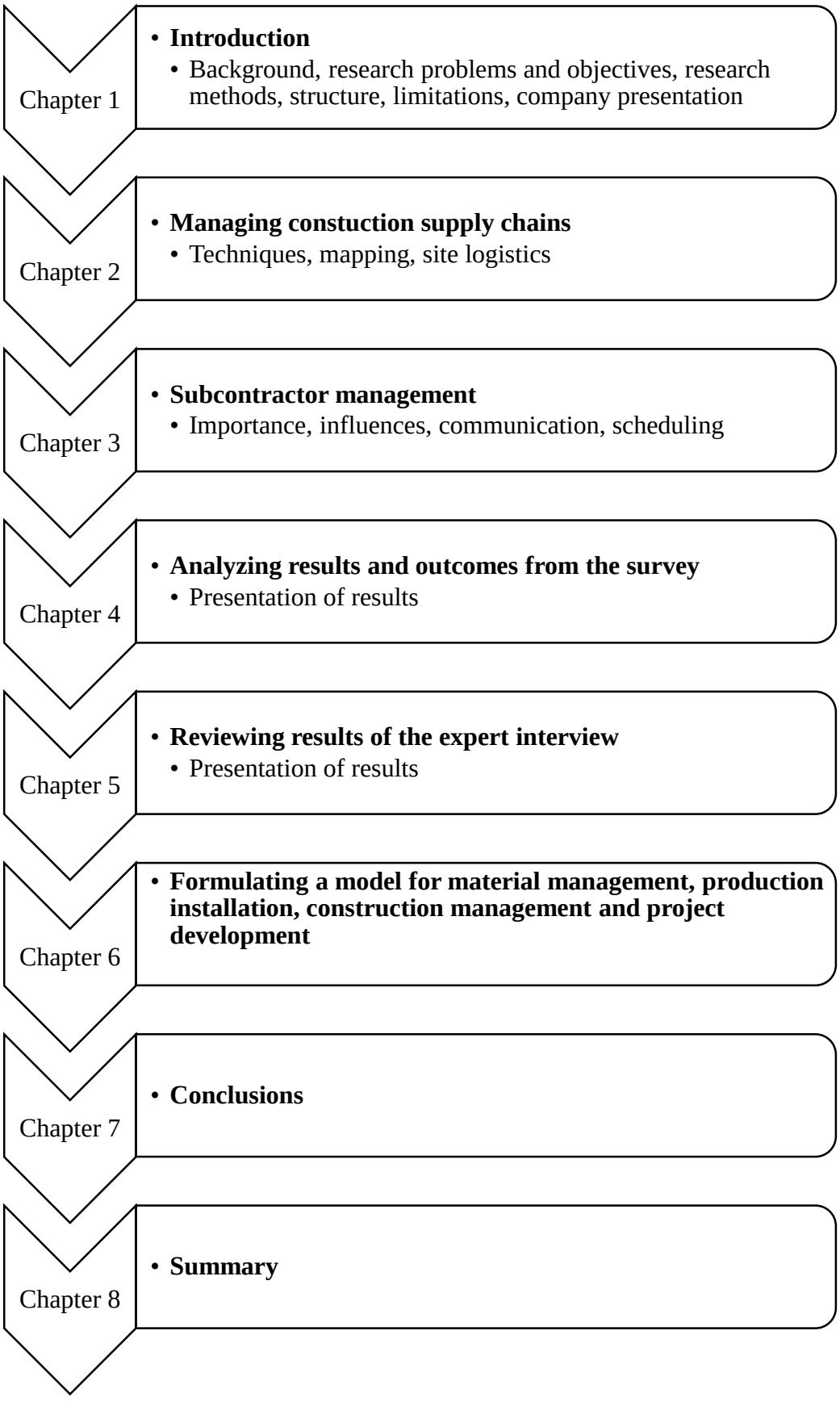

Figure 1. Research structure.

1.6.1 Relations between theory-based information and empiricism

A literature review is made for to support selected guidelines in the thesis and to give relations between literature and empirical studies. Relations are explained in figure 2. Feasibility of theories and best practices in construction project industries depends a lot from similarity. Sizes of the projects and working environments varies a lot and because of that applying theories is not a distinct task to do. Still all the regularity remains and the interfaces can be found in certain level.

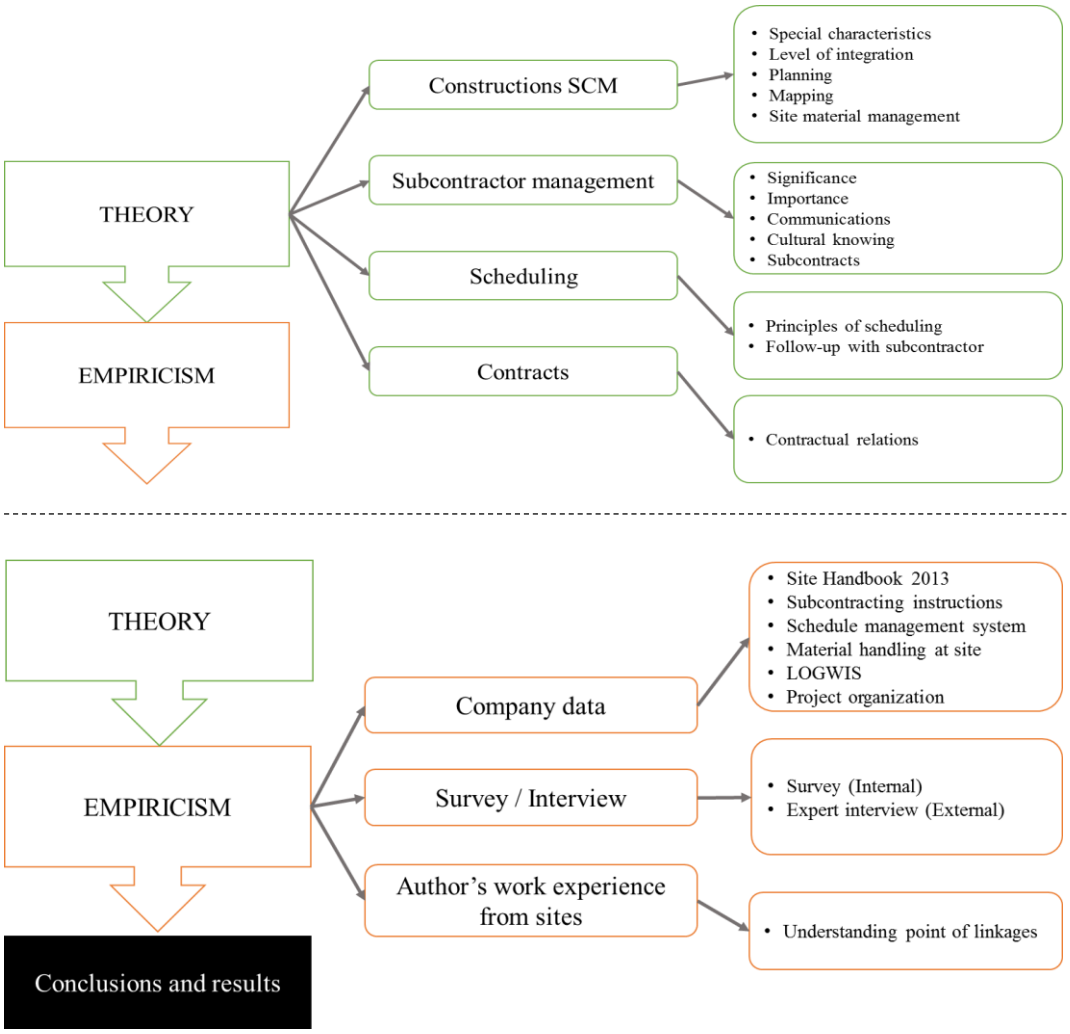

Figure 2. Connections between theory-based information and empiricism.

1.6.2 Limitations and boundaries for the project

This study considers only EPC projects. The contents have confluence also for other types of projects, but the focus is only in EPC projects due their special characteristics. The study will not show the interfaces for other project types. Projects will include only Wärtsilä's power plant projects although Wärtsilä supplies other products. This study is not concerning operative level instructions at site precisely. Supply chain parts outside the construction site will be limited from studies as it's already in good condition in Wärtsilä's processes. The company has invested in the development of those parts of a supply chain. Scheduling considers scheduling with subcontractor only. Limitations are illustrated in figure 3. Wärtsilä's project management and material deliveries are not inspected itself in this study, but linkages from information and communication flow are taken into account. Alike inspections are also dealt with customer relation and local material supply. The focus is on site functions.

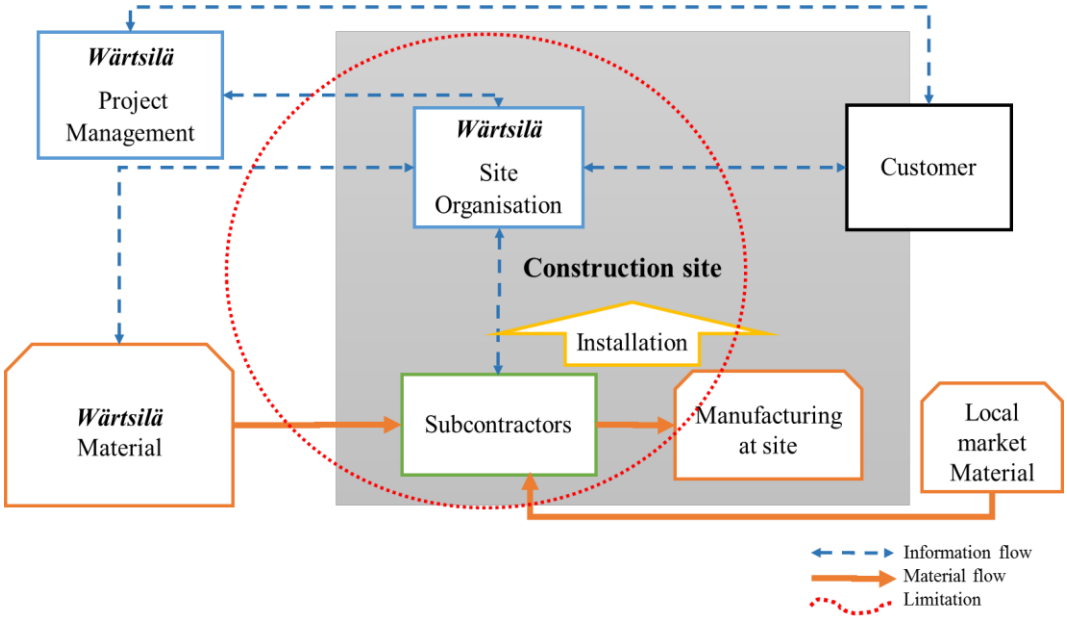

Figure 3. Limitations and boundaries for thesis.

2 MANAGING CONSTRUCTION SUPPLY CHAINS

Is it possible to implement best practices from manufacturing to the construction industry? Studies shows that Supply Chain Management (SCM) and Concurrent Engineering principles have possibilities also in construction sector. Implementing these practices beyond the company's boundaries is the key factor. Inter-firm projects doesn't have enough effect to the big picture. Main contractor's and subcontractor's performance in terms of quality, service and cost needs improvement in the construction industry. Performance improvements might be more effective when they are done in collaboration. Concurrent Engineering is a time compression technique. It's close to an inter-functional approach to process improvement. It requires close cooperation between organizations, in this case main contractor and subcontractor that the integrated developing process is possible to start. (Errasti et al. 2006, p. 250-256)

Supply Chain Management (SCM) has diversity of definitions and understanding presents a challenge. In this chapter we explore a wide range of conceptual issues that help us to understand the characteristics of supply chains in construction. Focusing in the supply chain gives effective ways for value creation for the clients to the company. Supply chain gathers innovation, continuous improvement and integration of systems. The effects of supply chain are industry-wide and gives high levels of profitability. Value creation is not just a process through a supply chain. Constituting network positions is not enough alone; supply chain needs to be supported from each link in network. Even the term *supply chain* is commonly understood as a linear process it exist only at high level of abstraction. When using adapting techniques of supply chain management it's notable that supply chain starts to form from different clusters instead of just a linear chain of different actors. In construction supply chain clients, consultants, contractors and suppliers are observed and their linkages containing knowledge transfer, information exchange, financial and contractual relationships. (Pryke. 2009, p. 1-2)

Actors of the construction supply chain are generally following relations illustrated in figure 5. Different processes are fragmented and relationships have become adversarial. Every actor must minimize the risk and maximize the reward. It means passing the risk down to the next level on the chain. This will mean increases of costs and reduced efficiency. Subcontractors focus is often in high utilization rate instead of completing tasks against the schedule. (Cox & Townsend. 1998, p. 31; Fowler. 2006, p. 283)

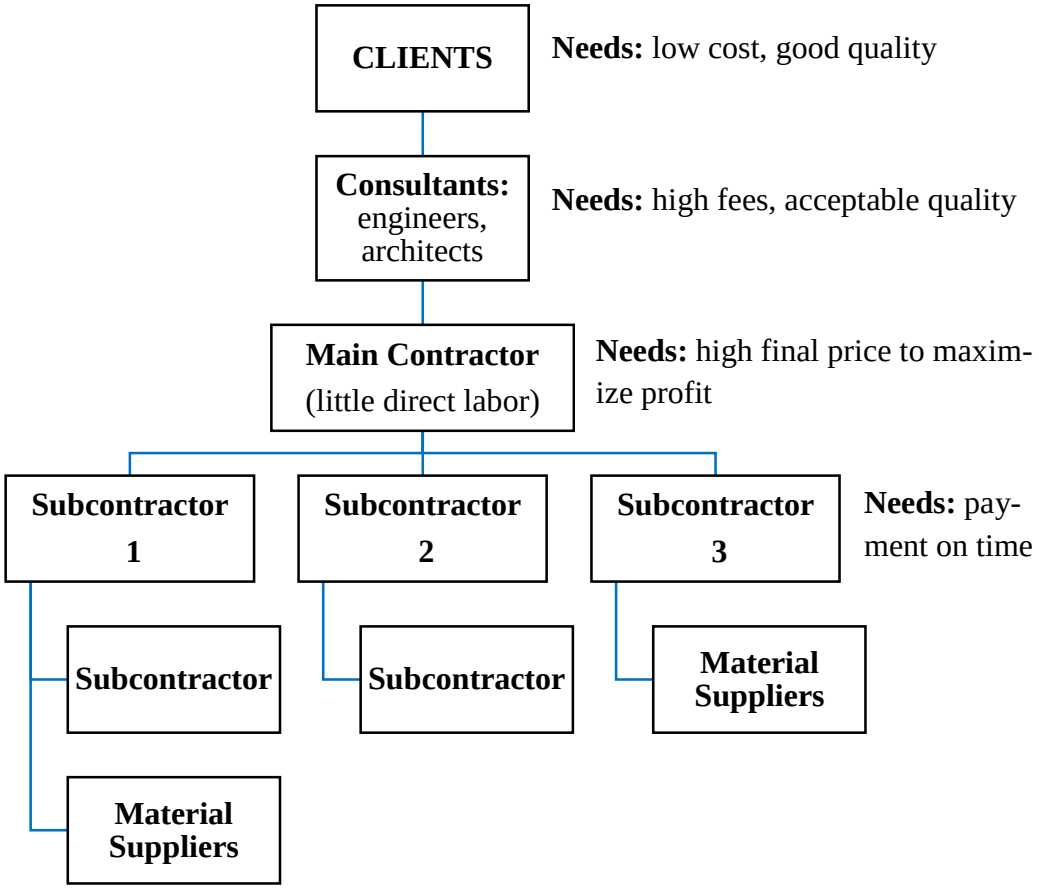

Figure 5. Existing industry structure. Modified. (Cox & Townsend. 1998, p. 33)

According to Pryke (2009, p. 9) SCM in construction is the most recent way to develop the industry. Benefits might be gained by adoption of the following features of SCM:

- "Acquisition of new suppliers through value based sourcing
- Organization and management of the supply chain to maximize innovation, learning and efficiency
- Supplier development and measurement of suppliers' performance
- Management of workload to match capacity and incentivisation of suppliers to improve performance
- Capture of suppliers' innovations in components and systems."

The construction industry is mainly a project based industry. Projects differs extensively from each other and their uniqueness can be determined by needed resources and selection of the significant supply chains. Uniqueness means that construction projects are often custom-made for client's specifications and requirements. The diversity of a project consists of materials and components engineered and produced by various suppliers and companies. Reorganizing versatility of assets for each new construction project causes difficulties as the fragmentary demand form client has to be coupled with supply chains. Moreover, supply chains in construction projects are complex due to growing change from on-site to off-site production. Value adding for the project scatters further off from construction site along the supply chains. (Jones & Saad. 2003, p. 12).

2.1 SCM management techniques in construction industry

Although, SCM plays critical in enhancing total performance of construction project it keeps still on a very early stage of development. Attitudes are still slowly changing and awareness to criticize current working practices. Development of SCM could be reasoned by rationalizing the supplier base, as many companies have done. SCM has been implemented successfully in manufacturing industry. Contrary to the manufacturing industry, the construction industry lacks standardization

which effects for the carrying out of the practices. The construction site is more likely an ad hoc factory, which produces makeshift prototype products. (Pryke. 2009, p. 33; Bankvall et al. 2010, p. 385-387)

There are five levels of maturity of SCM. Each stage implies the current state of integration. SCM maturity levels are defined in following, by Pryke (2009, p. 34)

- *"Level 1 – Ad hoc*

  The supply chain and its practices are unstructured and ill-defined. Processes, activities and organizational structures are not based on horizontal processes, while process performance is unpredictable. SCM costs are high, customer satisfaction is low, functional cooperation is also low.

- *Level 2 – Defined*

  Basic SCM processes are defined and documented, but the activities and organization basically remain traditional. SCM costs remain high, customer satisfaction has improved, but is still low.

- *Level 3 – Linked*

  This level can be considered a breakthrough where cooperation between company departments, vendors and customers is established. SCM costs begin decreasing and customer satisfaction begins to show a marked improvement.

- *Level 4 – Integrated*

  The Company's vendors and suppliers co-operate on the process level. Organizational structures are based on SCM procedures; SCM performance measures and management systems are applied. Advanced SCM practices, like collaborative forecasting with other members of a supply chain, forms. As a consequence, SCM costs are dramatically reduced.

– *Level 5 – Extended*

Competition is based on supply chains. Collaboration between companies is on the highest level, multi-firm SCM teams with common processes, goals and broad authority form. “

These five stages of maturity implicates the aspect of activities taken towards efficient SCM and developed processes. Predictability, capability, control, effectiveness and efficiency are the main contents for level. (Pryke. 2009, p. 34)

Pryke (2009, p. 34-35) explains the whole nature of formation of an ad hoc supply chain in construction industry to the point. Supply chains are often unmanaged and consists of multiple linkages and adversarial interests of actors.

> *“For years ad hoc supply chains of subcontractors are assembled and then disassembled at the end of each project. This basically can be attributed to the one-off nature of construction projects coupled with discontinuous demand. It can be argued that this type of traditional supply network is unlikely to maximize the value for parties involved in the supply chain.*
>
> *The traditional construction project supply chain can be described as a series of sequential operations by groups of people who have limited concern about other stakeholders. Most construction projects are procured through a method by which a defined project forms the focus for a building process carried out by a contractor, who traditionally obtains the work by bidding the lowest price for carrying out the project. The appointed contractor will outsource or subcontract the majority of the work to a number of relatively small subcontractors who will usually win the work on exactly the same basis. The number of subcontractors will vary with the complexity and nature of the project. These contractors and subcontractors typically focus upon meeting*

their contractual requirements for the lowest possible cost. There may be limited commitment to the client's primary objectives or to any perceived project team. A parallel, but separate supply chain managed by the client, or client's project manager, will in most cases include the procurement of the financial resources to support the project and the procurement of the design process itself.

Traditional unmanaged supply chains are characterized by short-term focus, with little concern for mutual long-term success; adversarial relationships between customers and suppliers, including win-lose negotiations; little regard for sharing benefits and risks; and primary emphasis on cost and delivery, with little concern for added value. As a consequence, the traditional supply chains in a construction project are complex and temporary, involving participants who may not contribute, other than to complete their small, often isolated, part of a one-off project. A team culture focused on the particular needs of the client or the project rarely exists. Different approaches to managing such a supply chain are therefore required if the potential benefits are to be achieved. The culture within which SCM can be developed may not exist in traditional procurement methods, but can be created if the value of such change can be shown to be significant.

Despite the limited value and benefits of the ad hoc supply chain structure, it has worked with varying degrees of success in construction projects, owing to the unpredictable nature of the construction process."

Designing management of supply processes requires involvement from construction specialists. Setting cost and time parameters is worthwhile doing with specialists as usually specialist carries out the most of the work in construction projects.

Specialist could be employed by the main contractor or the subcontractor. Subcontractor's specialists may have crucial advices which should be taken into consideration at an early stage. (Pryke. 2009, p. 38)

Usually management of supply is performed through a subcontracting process. The main contractor follow the traditional stages of a construction process; design, bid and build. This process is more a price focused and does not include specialists to give advices for management of supply at least from subcontractor's behalf. The only management of supply is made by contract specification. Traditional process does not give space for innovation and collaboration. To find new ways to manage supply and improve supply chains, attitudes towards processes has to be changed to more open-minded. Value creation from the project to the client can be made through new type of thinking focuses. (Pryke. 2009, p. 38-39)

2.2 Supply chain mapping in construction

Figure 6 illustrates three things that must be understood when mapping supply chains. Resources which are created and delivered, for example product or service, is the first thing. Secondly, the exchange relationships are important, between supplied resources and the flow of revenue. Thirdly, the ownership and control of supply chains needs to be considered. Then analytical mapping can be commenced for supply and value chains. (Cox. 1999, p. 173-174)

Due to uniqueness of construction supply chain can't be illustrated by an example that fits to every project. Figure 7 presents a generic supply chains in a typical project delivery solution, which have similarity to the most of the projects. In an ultimate level of complexity number of supply chains and integrated relation could increase in numbers. Specific requirements of an end customer are able to change the supply chains. Still, supply chain should first presented in rather simple way even the reality is quite different. (Cox & Ireland. 2002, p. 10)

Cox and Ireland (2002, p. 10) wrote that: “During the construction process, the end customer will appoint the construction firm and professional services where needed. Within the generic supply chain, the construction firm plays the major role in integration for all upstream supply chains. However, it should be noted that there is a high degree of subcontracting within the industry with main contractors appointing third parties to deliver packages that can be integrated within the solution. The use of subcontracting within the industry is further increasing the problems associated with aggression as there is another party in the supply chain who is attempting to earn margins to the detriment of other firms.“

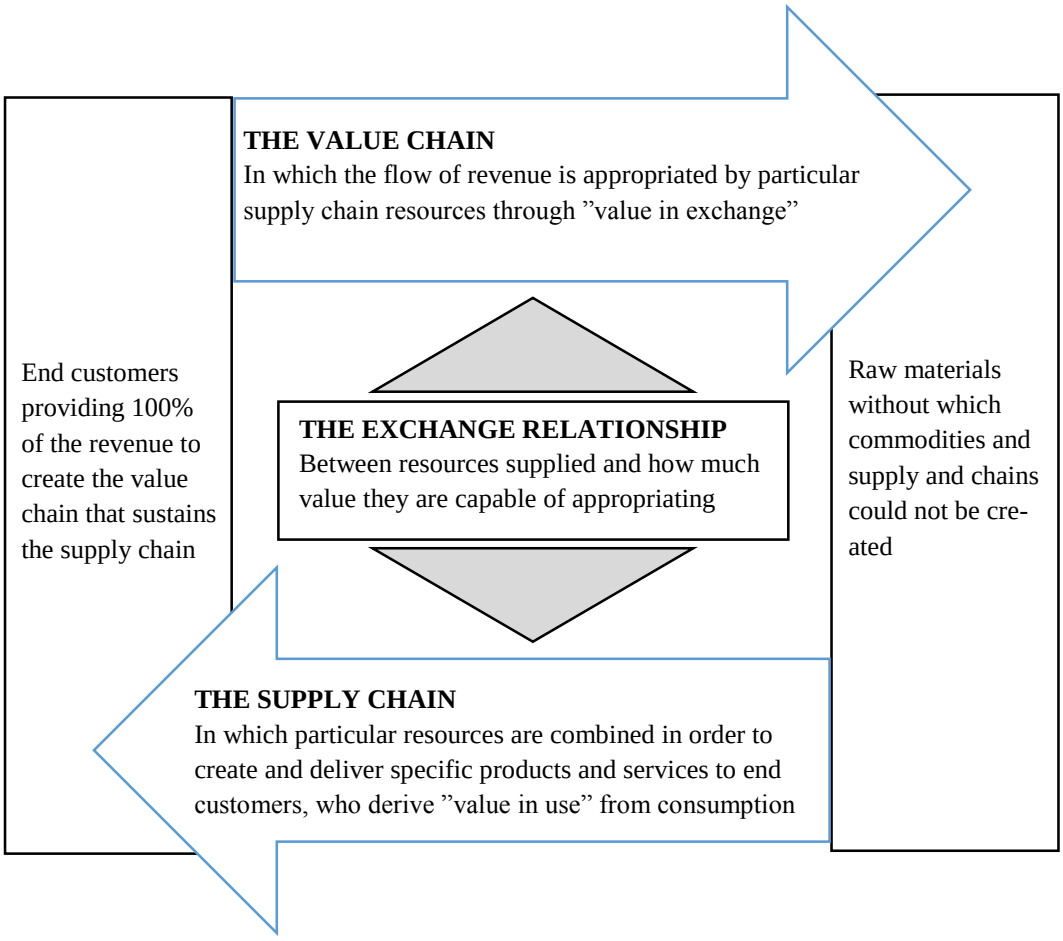

Figure 6. Supply and value chain mapping. Modified. (Cox. 1997, p.207)

Each construction project has requirements for materials, labor and equipment. Procurement professional have same challenges that those who are selecting the construction firm; supply chain for each requirement has to be known or it can’t be

managed effectively. If the construction firm could create a situation where the demand is regular for specific products and services needed could be mobile and used also in other projects, it would gain advantages for supply chain management. This requires understanding of conditions for the other parts of the supply chain. From the upstream supply chains the conditions are for example regularity and location. (Cox & Ireland. 2002, p.10 - 11)

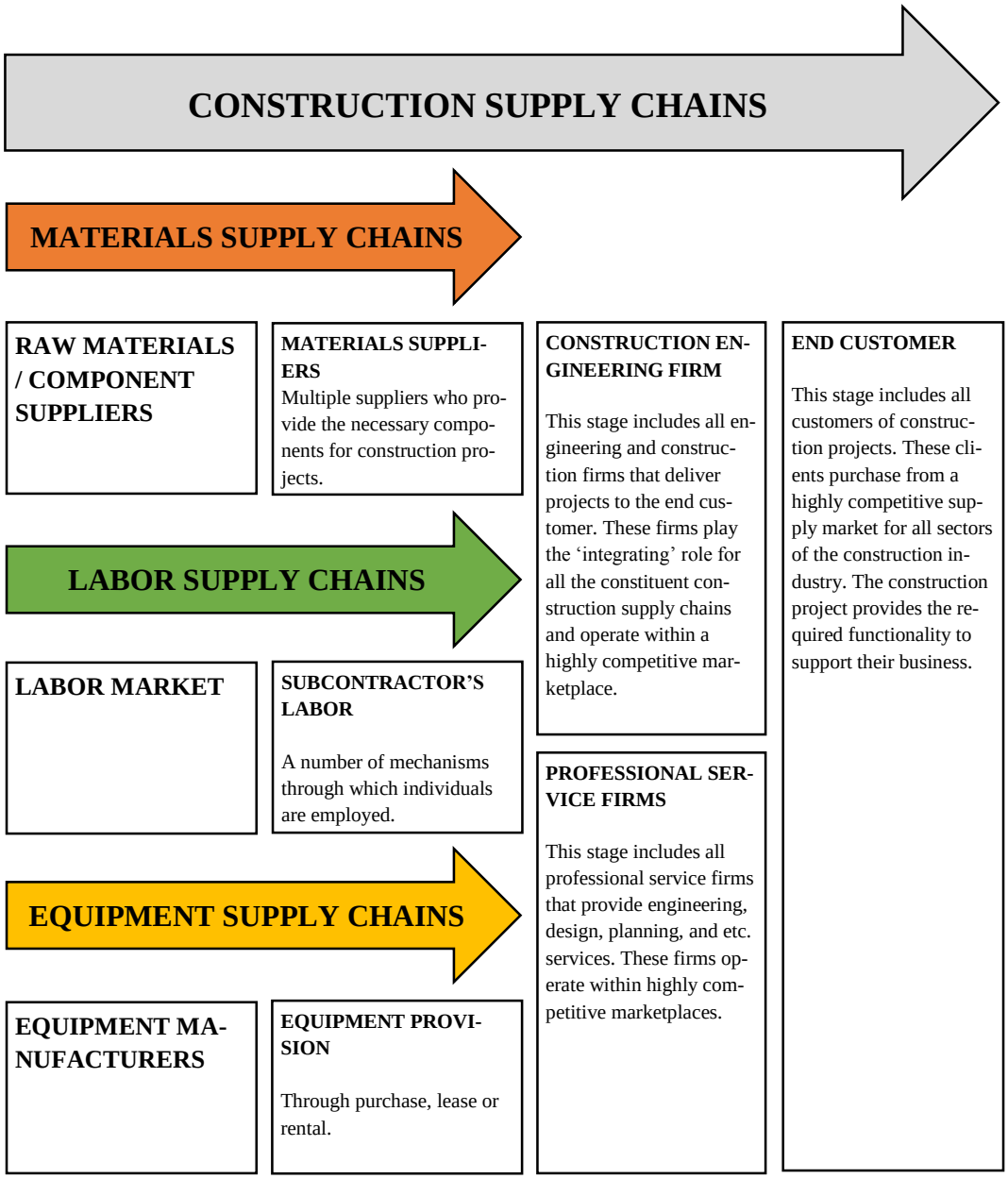

Figure 7. The multiplicity of construction supply chains. Modified. (Cox & Ireland. 2002, p.11)

2.3 Site material management

The responsible of procurement commits purchases in cooperation with the construction site personnel when the requirements from site are taken into account better. Requirements are recorded to the tenders and contracts. It is essential that the site personnel involved in the production and delivery management process for procurement planning. If possible, plans should be drawn up before the call for tender, that the data can be utilized in the negotiations and agreements. The information from made contracts and orders is given to the site supervisor, who is responsible for the current supply. The supervisor's role is to design implementation of measures which are dependent on the supply and communicate with the supplier. (Kemppainen et al. 2009, p.10)

Construction site logistics has to be designed in advance as well as delivery management that works on site will run gracefully. Logistical solutions need to be presented in the lifting plans and site area plan, which shows for example material storage areas, unloading areas, driving routes and workstations. (Ibid. p.10)

Site material management aims to ensure that the necessary materials are available at the right time and the work can proceed on the schedule. Management of deliveries allows the supply of materials to be suited for the need and the material does not get unnecessarily stored at site. (Ibid. p. 5)

Kemppainen et al. (2009, p. 3) suggest that construction site deliveries are being managed by:

- **Timing of deliveries** as per the necessary materials are at the right time the site and the work can proceed as planned
    - Acquisition plan
        - Supply schedule
        - Responsibilities of procurement

        - Site logistics planning
    - Communication with supplier for ensuring deliveries
    - Informing from changes in the schedule
- **By following the use of materials and demand** and by making changes to the deliveries accordingly
    - Weekly planning
    - Subcontractor meetings
    - Kick-off meeting
    - Delivery schedule
- **Informing from the changes of plan**

Managing deliveries is problematic, because usually at procurement stage consignment sizes differs from actual needs at construction site. Managing deliveries is not working if information from needed, installed and stored materials is lacking. Due to insufficient delivery control materials could be stored unnecessarily long on site, whereby the risk of damages increases. On the other delays on material supply causes delays for site works. Informing from changes is critical that the procurement section can react on time. Suppliers are also demanded to give enough feedback from deliveries that personnel on site can respond accordingly in their actions. (Kemppainen et al. 2009, p. 4). Kemppainen et al. (2009, p. 4) states that, problems in site material delivery are often caused by:

- Inaccuracy of planning, contradictions and delays
- Purchasing started too late
- Forgotten materials from procurement plan
- The supplier errors in the content delivery; packing, delivery time, and the notification of delivery date
- Quality defects
- Lack of information between the site personnel and the supplier, regarding changes in plans and schedules.
- Ignoring the latest amendments before ordering
- Extra work for shifting, protecting and storing spare materials

- Other subcontractors products in storage area

3 SUBCONTRACTOR MANAGEMENT

Subcontractor management has great influence for the value chain of an EPC project. Organic growth and acquisitions are influenced directly and indirectly by subcontractor management. With good management subcontractor will perform efficiently. This area need development though, studies shows that only a few companies are doing well in this area. Subcontractors might have problems to work with a positive cash-flow which is vital to their performance. If subcontractors client delays payments to cover up own ineffectiveness and cash flow, it creates negative impact to the whole value chain and endanger the project success. Impacts on value chain might effect to all the stakeholders on the project. Releasing payments to subcontractor on time might be better for the project to avoid stakeholder's loss. Sometimes delays may be a results of company's incomplete engineering and procurement instead of subcontractors defect on site works. (Pillai et al. 2010, p. 14)

According to Saqib et al. (2008, p. 392) the construction projects are completed as a results of a combinations of multiple events and interactions, planned or unplanned, with changing participants and processes in a constantly changing environment. Some factors in the construction project are more important than others, these factors are called critical success factors (CSFs). Saqib et al. (2008, p. 395) lists contractor-related factors in one of the CSFs. Contractor-related factors are explained in their research as follows:

"The main contractor and subcontractors start their main duties when the project reaches the construction stage. The variables include contractor experience, site management, supervision and involvement of subcontracting, contractor's cash flow, effectiveness of cost control system, and speed of information flow." (Saqib et al. 2008, p. 396)

The general contractor has a project management relationships or construction relationship with the other parties, when it's managing the whole construction process from start to the completion (Wilkinsson. 2001, p. 160). The characteristics of construction industry comprehends from, complex activities in a long-term projects. Activities and technologies are often outsourced due to the complexity and differentiation. The general contractor's task is to manage the construction supply chain and its actors which consists of subcontractors and specialists. How well the general contractor manages on coordination and collaboration could determine the success of a project in some cases. It's often argued that how important this could be in construction projects because of the temporary duration of a project. Forming trust-based relationships with subcontractor requires a lot of time and effort, but it's crucial for collaboration. (Ronchi. 2006, s.24) From the perspective of a project management company, the problems occurs in relationships with the other actors. Project management companies need to develop their strategies for dealing with these situations by analyzing the problems (Wilkinsson. 2001, p. 170).

Total quality of objectives of a general contractor depends partly on construction supply chain management. Therefore, supply chain management can point out imposing problems of the industry and its clients. Developing active structure and effective communication system is under general contractor's responsibility. Those are significant parts of project management. Partnering and coordination are contributing the success of a construction project and can be kept as key success factors. (Ronchi. 2006, s.25)

Some companies presents short-term collaboration with subcontractors and suppliers during the project life cycle as a key success factor. Practices differs from company to company, but especially managers in construction companies should understand practices from other actors that might be useful. Manager's plan of actions includes strategic issues such as supply chain management and customer-supplier relationships. Managing and building relations starts from selecting subcontractors and suppliers. It contains the managing of supply base, interacting and negotiating with suppliers and subcontractors. Managing work on the construction site produces

divergent contradictions; problem solving skills is one of the key success factors in the industry. Suppliers and subcontractors carry out actions that are critical to the project success, therefore keeping them under control needs continuous management. (Ronchi. 2006, p. 29-30)

3.1 Communication with foreign subcontractor

Using language in critical situations should be conscious. Communication happens at least between two parties and needs common understanding. The key aspects is to understand that one's monolog should be translated to a dialog. Common understanding is the first thing to prevent disagreements (Haapio & Sipilä. 2013, p. 354-358). Challenges in communication are emerging due to multiple inputs that are usually needed in construction industry to carry out a single task. Fowler (2006, p. 284) lists nine inputs which are included in executing tasks:

1. "output from preceding task;
2. materials;
3. labour;
4. plant;
5. information – what is needed to be done;
6. space – access to the working area and space in which to work;
7. method – as in how the works is to be done;
8. permissions – in terms of planning, building regulation and statutory authority approvals; and
9. environment – as in weather conditions."

3.2 Subcontracts in construction project industry

In international subcontracts and designing contracts are made with FIDIC-terms or adaptions of FIDIC. Making amendments to the terms of contract demands a lot of expertise. While using multiple document those reciprocal order of legitimacy could be and should be defined in the contract (Haapio & Sipilä. 2013, p. 61). The primary objective for the contracts is to guarantee accomplishment of goals and to

assure proceeding according to plan without surprises. Different parties have different interests regarding cash flow, risks and profitability. Function of contracts is to make interests visible and common. (Haapio & Sipilä. 2013, p. 92)

3.3 Scheduling in construction projects

Scheduling methods comes in many varieties therefore only the most common are introduced briefly. Scheduling methods are compared with production management requirements in table 1.

Critical Path Method (CPM) determines which activities are critical; failing in critical activities will often cost delay. Also calculates the amount of safety time before a non-critical activities need to be started. Major benefits are a disciplined method for planning, visible logic and construction methodology, the interdependencies between critical and non-critical activities. The Line-of-Balance (LOB) represents activities in their production rhythms. These rhythms are shown in a graph 'time x units'. LOB is easy to follow due to its graphical format. Other benefits are duration information at different productions rates. Critical Chain method is presented next. Construction planning through critical chain are similar to CPM, but safety times are not determined to each activity itself, only at the end of the chain. The critical chain is defined as shortest route through dependent activities. Last Planner System (LPS) is also a common scheduling method. Scheduling with Last Planner System starts from the tasks what should be done. Then it is determined which tasks will be done in a given time frame, because not all can be done due to resource constraints. LPS as a technique is quite straightforward, but implementing is harder, because it requires a lot of involvement. (Henrich & Koskela. 2005, p. 3-7)

Table 1. Comparison between Production Management Requirements and Methods. Modified. (Henrich & Koskela. 2005, p. 7)

REQUIREMENTS	CPM	LOB	Critical Chain	Last Planner
Delivering the product	**OK**	**OK**	**OK**	**OK**
Minimizing waste	**NO** It is not involved with the process, just with scheduling.	**POORLY** Produce a task flow for even and continuous utilization of resources (workforce, equipment, materials, etc.)	**POORLY** Paying attention to the constraints avoids the waste of waiting time.	**PARTIALLY** Reduces making-do* ;working backwards from a target completion date eliminates work that has customarily been done but doesn't add value.
Maximizing value	**IMPLICIT**	**IMPLICIT**	**IMPLICIT**	**PARTIALLY** By reducing making-do* kinds of waste, quality is increased
Design of Production Management System	**OK** Very useful to draft the first task sequence.	**OK** Flow concept.	**OK** Identify the tasks sequence and their constraints.	**PARTIALLY** Does not cover all project phases.
Operation	**POORLY** It is difficult to keep it up to date. Software is needed.	**PARTIALLY** It is difficult to keep it up to date. Software is needed.	**POORLY** It is difficult to keep it up to date.	**OK** Because it works directly with the lowest level of production
Improvement	**NO**	**NO**	**NO**	**OK** There is a learning process involved.
Peculiarities of Construction	**OK** Can be used with any kind of project.	**PARTIALLY** Some authors argue that it is just useful for repetitive projects.	**PARTIALLY** Useful just for complex projects.	**PARTIALLY** In projects driven by equipment capacity, it is not very useful.
Integration with all aspects of the Production System	**NO** It is not linked with resources supply and people.	**NO** It is not linked with resources supply and people.	**NO** It is not linked with resources supply and people.	**PARTIALLY** It involves people synergy, but not resources.

** Making-do - Tasks are started without all their standard inputs (materials, machinery, tools, personnel, external conditions, instructions, etc.)*

4 ANALYZING RESULTS AND OUTCOMES FROM THE SURVEY

4.1 Preface for the survey

The survey was made for Wärtsilä personnel who has experience on power plant project at site. The questionnaire were defined to figure out possible problems and to get ideas for improvement. The survey is available as an appendix 1. There were 18 participants, 8 Site Managers, 3 Site Planners and 7 Section Managers with average working experience of 15.5 years in Wärtsilä's projects.

Answering for the most survey questions could be written freely, but for some questions answering will be made by choosing a grade to describe state of affairs. The grades are explained in table 2. Participators could also mark if they feel that the question is highly important. Markings are showed in figure 8 below. Answers are collected together and showed in next chapter 4.2 Survey results. Questions belongs to five different categories. Each question starts with letter "Q" and category number and ordinal number. Categories are, subcontractor management, daily agreements, site logistics, scheduling and communication.

Table 2. Grades for survey questions.

No.	
0	Poor
1	Insufficient
2	Sufficient
3	Satisfactory
4	Good
5	Excellent

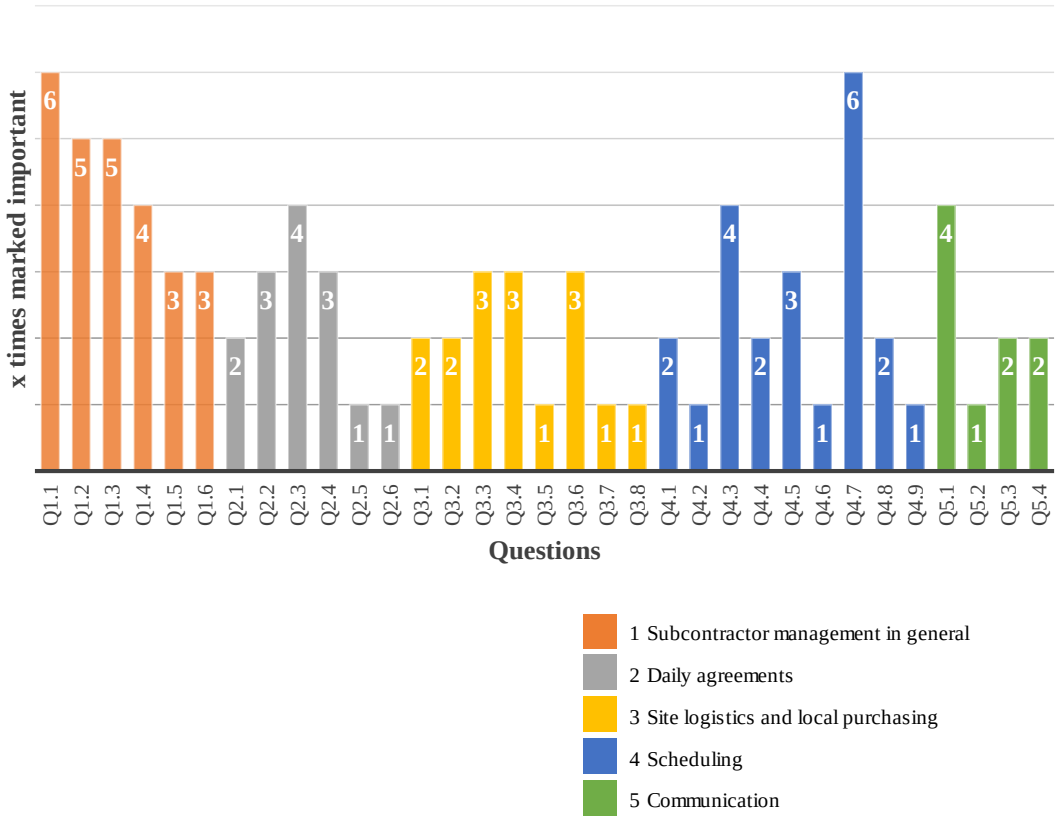

Figure 8. Importance of questions by participators.

Two of the most marked questions by importance were:

- Does Wärtsilä often end up to take responsibility for managing subcontractor?
- Is it easier to make scheduling with subcontractor with good relations established?

Clearly, the subcontractor management and responsibilities point out necessity for development. Subcontractor management is a base for other actions on site, therefore question regarding to that will most likely be the important ones. Participators thought that establishing good relations will make scheduling easier, which indicates the potential of mutual understanding for improving actions on site.

4.2 Survey results

Q1 Subcontractor management in general

Q1.1. Does Wärtsilä often end up to take responsibility for managing subcontractor?

Taking responsibility from subcontractor management is common in EPC projects. Sometimes total control is needed through detailed every day plan. The more experienced subcontractor is the less it needs to be managed and supervised.

Q1.2. Which matters cause above-mentioned situation?

In EPC-project one of main tasks is to synchronize contractors' works between the contractors, shipments and main schedule, hence the project schedules are tight. Lack of mutual understanding with subcontractors from developing countries is the most common reason when Wärtsilä have to use more time in subcontractor management.

Subcontractor is not enough organized and prepared. Their site supervision is unexperienced and inadequate, then Wärtsilä have to supervise the installation sequence. Subcontractor does not understand requirements for the project and they promise too much. Usually this is cultural related. Contractual details are unknown, because sometimes the contract is not made by executing organization on subcontractor side.

Wärtsilä's site persons should be prepared for local conditions and key persons must have enough skills for executing works at site. Wärtsilä should also avoid doing subcontracts with unfinished design. Low-cost subcontractors doesn't have sufficient skills in interpretation of drawings.

Q1.3. What kind of challenges are involved in subcontractor management?

Getting along with cultural and linguistical distinctions are current challenges. Commonly they effect for understanding of scheduling, moments in time, quality and safety issues.

If subcontractors are one-time contractors they will optimize their own profit and schedule, not Wärtsilä schedule. Subcontractors use undersized equipment and underestimated manning.

If Wärtsilä controls too much, subcontractor can waive their liability if something goes wrong. Subcontractors might also consider Wärtsilä's employees more as a foremen than supervisors.

Site manager has no control over subcontractor payments. 30 days payment via Finland is too long for many subcontractors. If subcontractor is not able to pay their workers or subcontractors no work will be done.

Wärtsilä needs skilled and experienced employees to deal with these challenges. Nowadays getting proper employees with practical and theoretical skills is challenging.

Q1.4. Does interpreting contracts and lack of contracts cause conflicts?

Wärtsilä's contract agreement template with subcontractor is too complex for small and unexperienced subcontractors. The contents of contracts could be more unambiguous. Generally, Wärtsilä's contract base is in good condition. The most conflicts can be usually settled at site. At least some of the site team member should be involved in drawing contracts.

Q1.5. Does Wärtsilä need to give instructions for subcontractor management in a construction site?

An instructions for installation sequence and installation manuals should be given to subcontractor. For labour control instructions are not needed.

If Wärtsilä gives internal instructions for subcontractor management they must be in very basic level due to differences in projects. More important is to give proper training for Wärtsilä personnel. Experienced and skilled site team can handle subcontractor management. Sharing experiences internally could be useful.

Q1.6. How well Wärtsilä is ready to take responsibility for subcontractor management?

Average 3,06 Median 3,00 Standard deviation 1,09

Q2 Daily agreements

Q2.1. Are daily contracts made with sufficient mutual understanding between both sides?

Daily contracts intrinsically aren't problem, there's enough mutual understanding. Daily agreements or task lists are usually made verbally every morning and important/exceptional tasks confirmed by e-mail.

Challenges are in overseeing that subcontractor doesn't deviate from agreed plan. Wärtsilä personnel must avoid conflicts between schedule and daily conversations or agreements.

Q2.2. What kind definitions would you make to improve daily agreements?

As a rule recurrent daily agreements are strong signal from incomplete plans from subcontract stage. If something will be agreed on daily basis, subcontractor must have enough time to be prepared.

There's should be reference to drawings on written agreements to avoid extra work. Also agreements should contain liabilities, types and amounts of equipment and labor and better details from installation stages.

Q2.3. Which matters are the most confusing in agreements with subcontractors?

Often generally written parts and schedules causes confusion. There are also problems with contract limits and simultaneous working.

Q2.4. Are areas of responsibility limited clearly in the agreements?

Boundaries and liabilities are not always defined clearly and modified to a specific subcontract as the agreements are somewhat standardized. To get better work specifications for subcontractors, information flow between site and designers might need improvements.

Q2.5. How well content of agreements is followed?

Average 3,13 Median 3,00 Standard deviation 0,89

Q2.6. How well agreed budgets with subcontractors hold up?

Average 2,88 Median 3,00 Standard deviation 1,15

Q3 Site logistics and local purchasing

Q3.1. Does subcontractors have a construction logistics plan?

Subcontractors have rarely any plans. They might not have enough information about materials. Plan needs to be updated almost daily basis due to material arrivals to site.

Q3.2. What should be the main contents of construction logistics plan for site?

- General layout plan
- Secondary layout areas
- Workshop plan
- Organization chart of logistics personnel (liabilities)
- Machinery plan
- Communication plan
- Material inspection and handover
- Heavy and large components

Installation sequence needs to be taken into account during packing and shipping. Storing areas needs to be large enough.

Q3.3. Are materials supplied by subcontractor tied to purchasing schedule?

Sometimes, depends on how quickly project starts.

Q3.4. What information is available in advance from materials produced/supplied by subcontractor?

Usually a lot of information is available, but only on demand. Problem is that the information could be incorrect. Wärtsilä should have test samples or submittals in advance from material needed.

Q3.5. How well subcontractors performs in material quality inspection?

Average 1,88 Median 2,00 Standard deviation 0,96

Q3.6. Should there be more control in quality management for material produced/supplied by subcontractor? How that should be done?

Wärtsilä should improve their own specifications for materials. Visits to local factories are highly recommend. If possible materials produced or supplied by subcontractor should be minimized.

Q3.7. What kind of problems amendment works cause to site logistics and purchasing?

Amendment works cause often changes to schedule or delays. They might also cause additional purchases. Local purchases are pretty straight forwarded, but additional purchases from Europe are more complicated due to delivery time and extra customs clearing works.

Q3.8. Does subcontractors use second tier subcontractors or sub-suppliers? Is this prohibited in contracts?

These sub-chains are accepted if informed and approved in advance. It causes more flexibility to subcontractor. Unauthorized use of next tier subcontractor is not accepted. Details varies in countries and contracts. Controlling these chains is hard because usually the second tier has not any language skills in English and their interpretation of drawings is poor.

Q4 Scheduling

Q4.1. Main task for the master schedule is to control the project flow. How well the master schedule controls the project flow?

Average 2,72 Median 3,00 Standard deviation 1,36

Q4.2. Is the schedule updated regularly?

Updating has to be done on every project, but practices differ from project to project. The main schedule is not always realistic, but schedules made for subcontractors control better the construction.

If site has a planner updating will be more frequent. Still, the schedule needs to be made soundly, because then the updating is easier.

Q4.3. Is the schedule and amendments agreed jointly with subcontractor?

The Schedule agreed with the client not always matches with the Schedule agreed with the Subcontractor. Most of the times this is an issue and it has to be negotiated or discussed with the Subcontractor.

Q4.4. What in your opinion is subcontractor's role in scheduling?

In principle subcontractors have to make their own schedules and present them to Wärtsilä as they know their capabilities and resources. Wärtsilä should only give the baselines. If subcontractor will not provide the schedule as per their contractual obligations, they must be penalized. This should be addition to the contract base.

Subcontractor's experience and culture has effect on schedule making. If Wärtsilä has to manage subcontractor's schedules a lot of subcontractor's commitment is needed.

Q4.5. Is the progress realistic given by subcontractors?

Given progress is way too optimistic. Again, a very cultural related issue. Wärtsilä's site personnel have to observe site works and compare them to schedules. That is their main task on site.

Q4.6. Are subcontractors making their own schedules in conflict with master schedule?

It's common problem if Wärtsilä has lost control and managing ability to subcontractors. Differences from schedules have to bring down on weekly meetings.

Q4.7. Is it easier to make scheduling with subcontractor with good relations established?

Good relations are precondition to project success. But relations shouldn't have negative effect on Wärtsilä's demands and requirements.

Q4.8. How would you improve fluency of scheduling between both sides?

- Schedule updates should be done as soon as there is new information available
- Having a dedicated scheduler, essential for bigger projects
- Openness between Wärtsilä and subcontractor
- Subcontractor's understanding for importance of scheduling
- Common progress indicators, objective estimation
- Weekly updates at least
- Anticipation, proper site surveys in project planning phase

Q4.9. How well agreed schedules with subcontractors hold up?

Average 2,17 Median 2,00 Standard deviation 0,99

Q5 Communication

Q5.1. Should meeting schedule be enough for managing subcontractor or would it be better to keep meetings at need?

Weekly meetings are time consuming, but it's a good way to keep things in order and synchronized. Subcontractor management should be also continuous via daily communication. Additional meetings should be kept in special occasions.

Q5.2. How would you improve communications channels?

- Persons in charge defined
- Decision makers of subcontractor must be at site
- Sufficient language skills
- More face to face communication, but official documents has to be made on important matters. Also improves traceability
- Clear communication between project team and site team and other parties.

Q5.3. Does unofficial agreements appear between Wärtsilä and subcontractors?

Sometimes only verbal agreements are enough for small things and gain trust. Not a problem at all.

Q5.4. How well language barrier is dealt with?

Average 2,94 Median 3,00 Standard deviation 0,97

5 REVIEWING RESULTS OF THE EXPERT INTERVIEW

5.1 Conduction of the interview

An interview was made for three experts who's had a lot of experience from international construction projects. The agenda for the interview can be found in appendix 2. The interview started by presenting the scope of this thesis. Then the conversation passed around given topics. Which were almost same than the categories of the survey, but dealt with wider approach. Some topics evolved during conversation. Findings from interview are looked through in next chapter.

Three interviewees were:

- *Teemu Lantto, M.Sc. (Tech.)*
  - Currently working as a Project Director in a construction company
  - 15 years of work experience related to international construction projects
- *Heikki Leinonen, B.Sc. (Tech.)*
  - Retired, past Project Manager at site
  - 32 years of work experience related to international construction projects
- *Matti Mantere, M.Sc. (Tech.), Finnish honorary title of Rakennusneuvos*
  - Leadership coach, past CEO in a global construction company
  - 30 years of work experience related to international construction projects

5.2 The expert interview in conclusion

5.2.1 Contracts and agreements

For preparation of contracts it's a good idea to take site personnel expertise and comments into account and it is justified that they or their representatives would be

present up to the final conclusion of the agreements. Then the "first-hand" information will be passed on directly to the site. Key thing is to get a continuum from declaring the contract to the site when construction begins. Implementation in practice is important. Decision making chain must not break down in any case. While making agreements a few things must bear in mind. The agreement must be made on the basis of own objectives and must support those. The goal is to reach a consensus among all parties so that everyone understands what has been agreed and avoid, at least, subsequent problems.

The termination of contract is time-consuming and in short-term contracts this is usually not possible so the contractor's choice and performance is emphasized. Therefore, searching for and selecting the subcontractor with adequate performance even if it is slightly more expensive than the cheapest possible, it can reasonable, if it’s not expected that the cheapest subcontractor could perform by the schedule. The civil construction is essential, because the civil work will begin on the first and the following steps are dependent on the progress of the civil work. The civil works can be divided into different subcontracts for example excavations, fills, piles, pipelines, underground cabling, roads, fields, foundations, structures, etc., if necessary.

The contract should include for example the documents listed below, which is in the same legal order in conflict situations, unless otherwise is not shown in the contract. YSE contract already provides that the commercial documents must be in first, before the technical documentation.

Contract Agreement (subcontract) and appendices:

1. Memorandum / The Minutes of Contract meeting
    a. Follow-up schedule could be included (Weekly and monthly meetings)
2. Conditions of Contract
    a. YSE / FIDIC / tailored especially for the contract in question
    b. Revisions of YSE or FIDIC -terms in additional records
3. Particular (Special) Conditions of Contract
4. Technical Specifications
5. Method of Measurements
6. Bills of Quantities
7. Payment conditions / Payment schedule
8. Drawings
9. Contract limits, etc.
10. Tender documents
11. Tender
12. HSE (Heath, Safety and Environmental Instructions)

The subcontract is tailored to own point of view as beneficial so that the subcontractor is manageable and controllable, and the fees are paid only of the work which has been carried out successfully. The main contract is made similarly as far as it is possible with the client.

The conditions of FIDIC contract are suitable for international agreements very well and they are ready to translations in several languages. Admittedly e.g. the subcontractor exchange takes way too much time so in this respect the conditions need to be altered to be more suitable. FIDIC Conditions in must carefully reviewed and made in each case the necessary clarifications and changes in e.g. the tender documents. Meeting practices is a good to include in the documents, for example, in the contract negotiation recorded in the minutes.

Figure 9 explains the forming of contractual structures and relationships. In the subcontract is defined responsibilities between the contractor and the subcontractor. Construction works can be divided into different contracts between different subcontractors. Dividing is made to get savings if the total contract is more expensive than subcontracts as well as in the total or large enough subcontractor is not available and to reduce risks if subcontractor fails. A good agreement is drawn up to own needs. A good agreement is reached, when we know what to buy and which has shown in detail what has been bought (or sold).

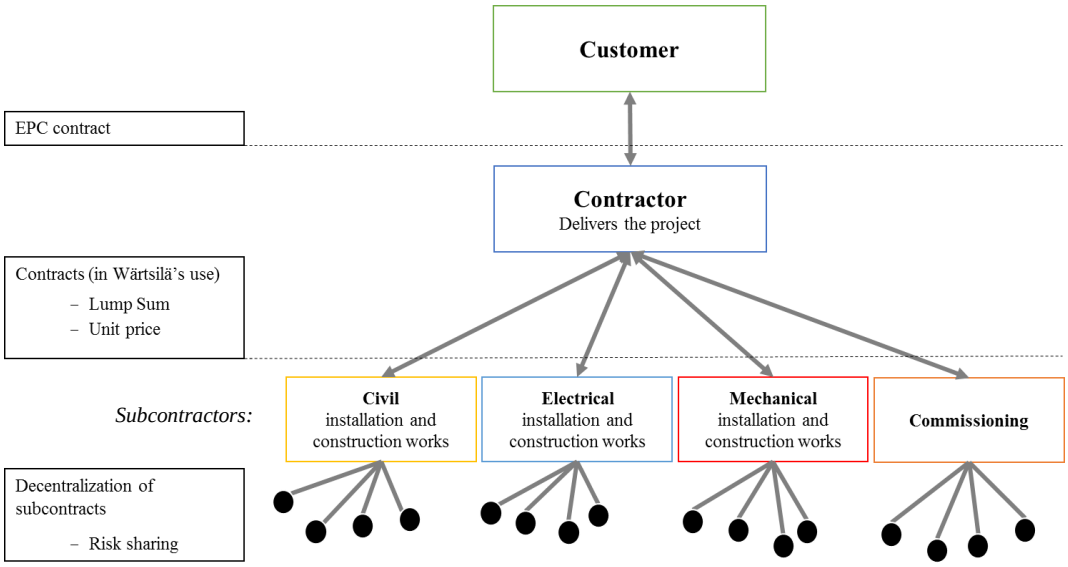

Figure 9. Contractual relationships and divergence of involved actors.

5.2.2 Reacting to altering situations

Reacting to altering situations on construction site has to be immediate. Reconstructive action must be negotiated or agreed with the customer or the subcontractor. Actions must be written for avoiding inconsistency in future with customer or subcontractor. Sharing of expenses due to actions must be determined, if it's not a lump sum contract. When using lump sum contract the contents have to be known that every work is invoiced and added to the constructions site's profit. All the extra and amendment works has to be measured and recorded. Notification from extra works and amendments has to be both sided and their signature are needed for documents.

When the documents are prepared in real time and in details they will save time from liquidation measures at the end. Real time reacting with written documents is the best way to avoid arbitration clauses.

It should be emphasized that with good preparation and exploiting opportunities during work gives the best techno-economic result for projects. There is always ways to save costs in big projects, but it needs experienced and business-oriented personnel to take advantage from those.

5.2.3 The subcontractor selection process

Selection of subcontractors for prequalification is the starting point for the subcontractor selection process. Therefore, this phase has to be made carefully as the results will follow with the whole process. It's important to find every potential subcontractor and not be too strict the first phase. If there's a lack of potential subcontractors the search have to spread out to wider area, for example to neighboring countries. Arriving to target area is critical for finding potential subcontractors, where better contacts are available to local organizations.

Representatives of site organization must be involved in the subcontractor selection process. Experienced members of site organization have skill for evaluating and understanding requirements. A ready-made agenda which contains the priority of matters should be reviewed with every qualifier. The priority matters could be for example human resources; workmanship, experience, equipment, references, liquidity, warranty. After prequalification risk analysis from each subcontractor should be made on the grounds of their review. The importance of the subcontractor selection could be explained by the damages to the whole project if the subcontractor is not capable and fails. Damaged could not be covered by the clauses in contracts if the subcontractor doesn't have liquidity.

At the tendering stage main contractor must be familiar with local conditions for example climate, soil and local authorities. It's also good to know local functions

such as suppliers, import duties and inflation risks. Knowing local conditions helps for choosing the most advantageous tender in techno-economic conditions. Back-up plan is needed for undesired situations and should be made as far as possible with the resources in use. Worst case scenario is changing the subcontractor among the unfinished work. The change of subcontractor has to be made possible in the subcontract concerning notice time and right to use the site area. Consequently, the project success does not endanger substantially.

5.2.4 Site personnel and site management

Management on site demands rapid reactions and fast decisions, without affecting negatively on the technical or economical outcome of the project. Best managers have good impressions from both outcomes. In the other words, even in the construction site good managers are businessmen that work for the ultimate profit, but bearing the technical quality in mind. Human relations skills, competence for guidance and ability to react in real time are also required skills from a manager. Not to forget about cultural skills which might have crucial effect in global projects. Sharing knowledge internally is vital for maintaining project knowhow inside an organization.

When manning a project it should be known that the experienced supervisor may manage with work supervising, but could groan with project management and subcontractor management. It could appear in contractual problems or inability to react subcontractor's actions. The problems may accumulate as a consequence and fixing them requires a lot of extra work. With avoiding extra works numbers of costs could be saved. The responsible in project management or in site management must control that the subcontractors are under supervisor's possession. The subcontractors will abuse opportunities for their benefit if not controlled properly.

Work supervising is based on prepared plans and agreed contract specifications. Therefore, supervisors must know the exact content of subcontracts. The best result

will be achieved by going through the whole subcontract with appendices from sentence to sentence between project manager or site manager and supervisor. Supervisors must have the same understanding that the executives in project organization. When the construction work has begun supervisors must demand and follow that the subcontractor has the promised human resources and equipment on site instead of just written in contracts. Supervisor's work focus should be in subcontractor management and project supervision rather than stuck in devalued matters.

5.2.5 Site logistics

The planning of site logistics starts already while making the terms of main contract and should be almost ready when tendering subcontracts. The construction site area is defined in the main contract and therefore it give the first logistical guidelines. Area must be adequate for all the equipment and material storing. Planning should be made in cooperation with site personnel and responsible of deliveries.

Materials supplied by subcontractor must be inspected beforehand installation. Technical specifications, drawings and submittals are demanded from the subcontractor. Consequently, required specifications can be confirmed. Factory and work shop visits are recommend for quality control. Test results should be accepted only from independent institutions.

5.2.6 Scheduling site works

It's important for the project management that the subcontractor obey the schedules. Schedules doesn't have much space for negotiations as the outlines comes from the customer. In delay cases, amendments are needed in written so those could be useful arguments when reviewing contracts. Subcontractor's promises on process must have some real foundation to be credible. Verifying subcontractor's resources and estimating the duration of current tasks will give better understanding to control the construction process. Schedules should be based on revised information. Reaction with reconstructive actions to delays has to be immediate. When subcontractor gives new schedule the effect to other works have to be taken into consideration.

Good relations with subcontractor will help communication which is needed in scheduling. Mutual understanding is important in scheduling and removes the need for interpretation. Increasing cultural knowledge will assist the forming of good relation which will help the communication. Effective communication is especially significant for scheduling, but gives support to entire management process of sub-contractor.

6 FORMULATING A MODEL FOR MATERIAL MANAGEMENT, PRODUCTION INSTALLATION, CONSTRUCTION MANAGEMENT AND PROJECT DEVELOPMENT

6.1 Discovering targets for development

Reflecting theories and best practices from literature to Wärtsilä's projects awakes an interesting question. What are the benefits and is the profit measurable? Managing construction supply chains during project may not be beneficial due to the amount of effort it needs compared to the length of the project. Wärtsilä's projects are relatively short in time. Developing cooperation with subcontractor might not gain profit during project. This thesis suggests to take the most important parts of presented theories and practices and shows basic ways to implement those. Implementation of ideas are shown in chapter 6.3 the model for developing site operations.

Taking control over the construction supply chain is of the main targets for development. Identifying the level of integration that can be achieved with subcontractor has also potential for development. Supply chain could be observed in separate parts where material is only one of them and equipment and labor is also divided to their own supply chains.

For site logistics presented theories shows up simple lists of matters for creating functional material handling at site. Those can be implemented as it is because the survey shows that some kind of logistics plan is usually needed. Having it done properly needs planning in advance, even in the contract preparation phase.

Subcontractor management itself is a difficult area if it is observed on operational level. The survey and interview shows that subcontractor management at site level is more like the expertise of the main contractor's personnel than an area that can be planned in advance. To get this expertise to same level on every projects requires internal sharing of information.

Even the subcontractor management is the part which cannot be identified with straightforward operational guidelines, it can be identified as a pack of other areas which might help controlling the subcontractor. Developing cultural knowledge will help communication and building relationships. Better communication and relationships will help scheduling and making of agreements. Overcoming problems with language barrier will have same effects than better cultural knowledge, the communication is improved and relationships will deepen.

6.2 Framework for the model

Wärtsilä has internal instructions and they are taken into account to avoid conflicts. The model is built with this existing framework of structures which not necessary need changes. For example some development methods involves personnel requirements, but the existing organizational structures of project team and site team are suggested to remain the same. Internal instructions are handled as interfaces for the model. Interfaces from Wärtsilä's practices are shown in the model.

6.3 The Model for developing site operations

The model for developing site operations has multiple points that have influence on the project and are required to be timed on the right phase of the whole project. The project phases are shown in table 4. These are the common phases of the construction project. Phase zero means internal planning and developing of common instructions for projects in general. Each phase is marked in individual color and number which are used also in table 5 where *the model for developing site operations* is presented. Phases indicate when the specific area of development and procedures have to be started. New procedures are explained more precisely in subsequent chapters. Chapter headings are same than in the table.

Table 4. Project phases.

Internal development for projects	*Project Planning*	*Project Execution*				*Evaluation*
		Procurement	*Logistics*	*Subcontracting*	*Installation and Commissioning*	
0	**1**	**2**	**3**	**4**	**5**	**6**

Table 5. The Model for developing site operations.

Phase(s)	*Interface from Wärtsilä's instructions*	*Area of development*	*New Procedure*	*Definitions for procedures*
Selection of the right subcontractor				
4	Subcontractor instructions	Subcontractor selection	Risk analysis	– Evaluating risks subcontractor's current performance – Site personnel involvement during process
Getting the most out of subcontractor management				
0 **1**	*No given instructions*	Subcontractor management	Preparation for subcontractor selection	– Internal sharing of knowledge and experiences – Cultural competence
5	*No given instructions*	Subcontractor management	Memorable matters in site management	– Continuous evaluation of subcontractor – Operational knowledge is Wärtsilä's key success factor → Understanding value – Developing positive work relationships Real-time reaction to subcontractors actions

Phase(s)	*Interface from Wärtsilä's instructions*	*Area of development*	*New Procedure*	*Definitions for procedures*
Taking over the construction supply chain				
3 4 5 6	*No given instructions*	Construction supply chain management	Level of integration with subcontractor Overseeing subcontractors actions	Opportunities depends on: – Length of contract – Level of commitment – Forms of cooperation – Current supply environment Fulfilment of agreed plans: – Types and quantities of equipment and labor – Submittals of material – To check that subcontractor has enough resources and quality is on applicable level
1 2 3	Site material management (Site handbook) Site logistics Site orders (LOGWIS)	Construction supply chain management	Pre-planning site logistics plan	– Enough space at site, required on contract – Plan for materials stored at site, large components supply and equipment (cranes) taken into account

Phase(s)	*Interface from Wärtsilä's instructions*	*Area of development*	*New Procedure*	*Definitions for procedures*
Developments for scheduling				
1 **5**	Schedule management handbook	Project Schedule	Managing / Planning project schedule with subcontractors	– Using a dedicated scheduler as a best practice in large scale and complex projects
4 **5** **6**	Schedule management handbook	Work scheduling at site	Clear distribution of liabilities Installation sequence	– To avoid situation where Wärtsilä controls too much – To follow agreed plans – Giving enough information to subcontractor for executing construction properly
Understanding contracts and agreements				
1 **4**	Contract agreement	Contracts	Drawing up subcontracts	– Thorough rooting of documents with supervisors
5	*No given instructions*	Daily agreements with subcontractor	Considered agreements Achieving common understanding	– Schedules and material deliveries are taken into account when making agreements – Good relations; overcoming problems with language barrier and cultural differences
Designation of site personnel				
0	Site Handbook 2013 3.3 Site Management	Site personnel	Selection of site personnel	Business orientation: – More profitable contracts and agreements – Different perspective for executing the project

6.3.1 Selection of the right subcontractor

Proper subcontractor selection is critical for successful project. When implementing risk analysis to selection process, the worst subcontractors might be avoided. In risk analysis subcontractor's costs and performance are compared. This will drop the subcontractors from selection whose costs-to-performance –ratio is not applicable. Site personnel and at least Site Manager must be involved in the process. They have better touch about the needed requirements and also skills for evaluating subcontractor's performance.

6.3.2 Getting the most out of subcontractor management

Most problems during managing subcontractor are related to lack of mutual understanding. Mostly it depends on cultural differences. When one is having enough cultural competence it's more likely to comprehend different ways of working. Usually site personnel with more experience knows how to deal with cultural related issues. Internal sharing of these experiences is crucial for developing site personnel's subcontractor management skills. These skills can be used in subcontractor selection phase for evaluation of the subcontractor. Subcontractor management can't be planned in advance, but preparation can be started with gathering enough cultural competence and adopting knowledge from other's experiences.

Subcontractor management at site consist of operational level actions that differs from project to project depending very much on culture. Good work relations will make managing and communication easier. Site personnel must understand the value of developing and maintaining positive relationships. One of Wärtsilä's key success factors is that how to manage with different subcontractor's at site level. Interacting and communicating with subcontractor requires skills that are critical for site personnel. These skills can be improved with continuous evaluation of subcontractor. Continuous evaluation also helps to react subcontractor's actions rapidly. Real-time reaction gives more time to make decisions before things go totally

out of a track. Situation where subcontractor dramatically fails have to be avoided because it might affect to the whole project.

6.3.3 Taking over the construction supply chain

Wärtsilä need to integrate with subcontractor in a level that suits the best for individual project. Working ad hoc is suitable if it's justified by the short length of contract, incapable cooperation skills of subcontractor or it has only minor effect on the project scale. Having all supply chains evaluated and forming close relationship with subcontractor is also suitable if the benefits can be identified. Supply chain cooperation with the subcontractor have to be started at the very early stage. The main idea is to know beforehand where the supply of materials, equipment and labor is from. It gives better control over quality management and gives support for scheduling when more detailed information is available. Resources to analyzing and planning construction supply chain are in use also without knowing. It requires a little effort to clarify the supply methods from subcontractor. When subcontractor's supply methods are discovered it requires controlling and supervising on operational level that subcontractor is proceeding as agreed. Material supplied by subcontractor can be controlled by making factory visits and demanding submittals of material in advance. Controlling equipment and labor supply needs more effort before the work has started. Equipment have to fulfil given requirements and labor have to have enough skills for specific works. This have to be verified already in subcontractor selection phase. The key principle is to include plans for material, labor and equipment to the supply chain inspection.

Site logistics plan is not used in every Wärtsilä's projects, but could be beneficial even in the smaller projects as pointless relocation of material and equipment might be avoided. Planning site logistics have to be taken into account in very early phase after project kick-off. Usually geographical area for the project is defined in main contract. While making the contract is good to have some leverage for demanding reasonable area for the construction site. The more information is available of sizes

and quantities of materials and number of concurrent containers at site and equipment use the more leverage could be maintained on the contract negotiations. Site logistics plan is not stable during project due to constant use of material and equipment movement. Therefore, installation sequence must be coordinated with delivery order for not wasting the space in construction site. This matter needs more large-scale examination and operational level instructions are not given in this thesis. To get responsible site persons planning site logistics properly and to update the plan when needed is biggest challenge. Properly made logistics plans have also great value afterwards if they will be used in development projects.

6.3.4 Developments for scheduling

The surveys shows that using dedicated scheduler for project scheduling can be kept as a best practice, especially on bigger projects. Dedicated schedulers should be used in every complex project, otherwise scheduling could remain under site manager's or site engineer's responsibility as in current practice of Wärtsilä. Schedulers are inexperienced at the moment and working in smaller and relatively undemanding projects, could be kept as a training. Dedicated scheduler can keep better track on progress and present it to site team and subcontractors.

Scheduling site works with subcontractor belongs to Wärtsilä's supervisors. They have to show liabilities clearly to subcontractor that they know what area of construction they have to control themselves. If Wärtsilä controls too much site works scheduling, subcontractor may not take responsibility from its actions. Main task for Wärtsilä's supervisors is to follow that site works are executed by the agreed schedule. To make subcontractor taking more responsibility it's in Wärtsilä's account to give enough information. Informing subcontractor from installation sequence could be useful as the subcontractors may not have executed that demanding works before.

6.3.5 Understanding contracts and agreements

Well-made contracts are not enough if the contents are not clear to the supervisor and work executor. Rooting through the contents of subcontract with site team can be used as a best practice. When the contents are known it will be easier to manage and follow how the subcontractor is progressing in construction work. It is also easier to supervise labor and equipment resources when agreed specifications are in awareness.

Managing to make satisfying daily agreements with subcontractor is achieved through mutual understanding. The best instructions for making daily agreements is that the formerly agreed schedules and material deliveries have to be taken into account for avoiding conflicts.

6.3.6 Designation of site personnel

Almost every development suggestion is dependable on personnel skills. Therefore, designated persons for site team have to fulfill the requirements. Not only language skills and technical knowledge is needed, but also cultural competence, communication skills and understanding contract management have significant influence. Business-oriented persons would be best choice for manager roles. Contracts and agreements made would be then more profitable.

7 CONCLUSIONS

7.1 Evalution of results

The results of this study can be kept trustful as them are based on experienced personnel's knowledge from the industry and scientific studies. The sample of survey was quite extensive as half of Wärtsilä's experienced site personnel were participating. All the interviewees gave also a considered information as they have been also involved in developing site practices. Implementing of results could place a challenge as the operational environment of Wärtsilä's project varies a lot.

This study shows that improvement of site operations requires a lot of planning in advance. The most of the development proposal has to be taken into account in early phases of a project. Standardizing operational principles could help the improvement in the entire industry. SCM performance is essential for project success, but still seems to be at a very early stage of development. Implementing SCM related development proposals needs careful follow-up. Training of site personnel should be oriented to understanding a projects value creation mechanics. Then everyone would have the same focus in project on a large scale. Continuous development would point out problems in the future and the reactions could made accordingly.

7.2 Further study

Development proposals were not suggested to every inspected matters, as they are extensive in its entirety. Instead, they are suggested to be inspected in further study. Segmentation of projects with geographical or cultural differences could be done in the future as it may give more detailed information what kind of a challenges are related to the project environment. Regarding the survey, there might be some issues in information flow between site and Wärtsilä's design team and it should be inspected in its entirety. Using contractual matters in subcontractor management has also space for improvement and could be examined later on. Delivering orders depending on installation sequence needs improvement as per site personnel, but it

needs to be inspected how it effects on expenses. Implementation of supply chain integration needs also further inspection as this thesis gave only general guidelines. Opportunities for integration varies on current project conditions, so that is why general guidelines are not enough for effective implementation. Also, the output and the benefits from integration must be bring out in understandable way.

8 SUMMARY

In this thesis site operations in Wärtsilä's EPC power plant projects were inspected and developed. Site operations were divided to subcontractor management, site material management and scheduling with subcontractor. The objective of this thesis was a model for developing site operations, which formed via two research questions: Which matters effect on planning site operations in EPC projects and how these could be improved? Internal survey pointed out current problems on above-mentioned operations and gave some ideas for development. External outlook to the thesis achieved by interviewing three experts with work experience from global construction projects. Literature study gave expertise to understand the big picture of construction projects and some theories were discovered which could be applied to the model. Results from the survey, the interview and literature study created the model for developing site operations with a help from supervisor and author's expertise. The lack of mutual understanding between Wärtsilä and subcontractor for executing site works was the most important outcome from the survey. If the subcontractor is performing well and is more like a self-driven it doesn't need to be managed that much by Wärtsilä, but in a situation where subcontractor needs guidance, it's difficult to apply because there isn't common way of work. The interviewees thought that successful projects needs site personnel's involvement from the beginning of a project and cultural know-how. From literature, the main finding was integrating with subcontractor for improving supply chain management. Integrating will give better control over the supply chain, but still place challenges for relatively small projects.

The most important findings were that the subcontractor management process is a continuum from project start to the end and requires careful planning in early phases and constant supervising on later phases and the communication is a key for success in contract making and scheduling with subcontractor. New procedures suggested to subcontractor management are internal sharing of knowledge, keeping control over subcontractor with site management and making of risk analysis in subcontractor selection phase. When drawing up a subcontract it's recommend that the documents will be rooted thoroughly with supervisor afterwards. Planning of site

material management has to be started on early phase of a project for achieving sufficient space for site materials. With prepared plans subcontractor could be integrated into the supply chain management process of a project. Level of integration will depend on current opportunities, like the length of contract. Supply chain should also be defined for equipment and labor for controlling the quality offered by subcontractor. Regarding the survey, a dedicated scheduler is strongly recommend on a large scale projects. Other suggested procedures for scheduling are clear distribution of liabilities between Wärtsilä and subcontractor that situation where Wärtsilä controls too much will be avoided. All of these new procedures requires skilful site personnel so forming a team with right skill set is the base for project success. The interviewees highlighted the meaning of business oriented personnel in projects; contracts and agreements will be more profitable. Business orientation is strongly recommend on a manager level.

Implementing new procedures from the model for site operations will lead to lower variable costs especially on bigger projects as the projects are more planned and ad hoc works are decreased. Uncertainty of scheduling will increase due to better control over the subcontractors and more considered agreements. Benefits are also gained from internal sharing of knowledge as the expertise stays in-house. These matters will step up the overall quality of delivered projects.

REFERENCES

Ander, E., Roger, B., Aitor, O. & Javier, S. 2006. A process for developing partnerships with subcontractors in the construction industry: An empirical study. *International Journal of Project Management*. Vol. 25, No. 3, pp. 250-256.

Anttila, P. 1998. Tutkimisen taito ja tiedon hankinta. [WWW-document]. [cited 26.3.2015]. Available at: https://metodix.wordpress.com/2014/05/17/anttila-pirkko-tutkimisen-taito-ja-tiedon-hankinta

Artto, K., Martinsuo, M. & Kujala, J. 2006. Projektiliiketoiminta. Helsinki, WSOY Oppimateriaalit Oy. 416 p.

Bankvall L., Bygballe, L. & Jahre, A. 2010. Interdependence in supply chains and projects in construction. *Supply Chain Management: An International Journal*. Vol. 15, No. 5, pp. 385-393.

Baram, G. 2005. Project Execution Risks in EPC / Turnkeys Contracts and the Project Manager's Roles and Responsibilities. *AACE International Transactions*, pp. 05.1-05.8.

Cox, A. 1997. Business Success: A Way of Thinking about Strategy, Critical Supply Chain Assets and Operational Best Practice. Stratford-upon-Avon, Earlsgate Press. 327 p.

Cox, A. 1999. Power, value and supply chain management. *Supply Chain Management: An International Journal*. Vol. 4, No. 4, pp. 167-175.

Cox, A. & Ireland, P. 2002. Managing construction supply chains: a common sense approach. *Engineering, Construction and Architectural Management.* Vol. 9, No. 5, pp. 409-418.

Cox, A. & Townsend, M. 1998. Strategic procurement in Construction: Towards Better Practice in the Management of Construction Supply Chains. London, Thomas Telford Publishing. 360 p.

Eriksson, P. & Pesämaa, O. 2013. Buyer-supplier integration in project-based industries. *Journal of Business & Industrial Marketing.* Vol. 28, No. 1, pp. 29-40.

Fowler, A. 2006. Efficiency versus effectiveness in construction supply chains: the dangers of "lean" thinking in isolation. *Supply Chain Management: An International Journal.* Vol. 11, No. 4, pp. 283-287

Haapio, H. & Sipilä, R. 2013. Sopimusten ja häiriötilanteiden hallinta rakennusprojekteissa. Helsinki, Tietosanoma Oy. 485 p.

Henrich G., & Koskela L. 2005. Production management in construction – requirements and methods. Research in University of Salford.

Jones, M. & Saad, M. 2003. Managing Innovation in Construction. London, Thomas Telford Publishing. 306 p.

Kemppainen, J., Koski, H. & Palolahti, T. 2009. Rakennusmaantoimitusten ohjaus. VTT report.

Pillai, M., Sandelands, E. & Ashokan, G. 2010. Developing the EPC value chain in the upstream oil & gas sector in Middle East. *Oil and Gas Business.* Vol. 10, No. 2, pp. 1-22.

Pryke, S. Construction Supply Chain Management: Concepts and Case Studies. London, Blackwell publishing Ltd. 230 p.

Ronchi, S. 2006. Managing Subcontractors and Suppliers In The Construction Industry. *Supply Chain Forum An International Journal.* Vol. 7, No. 1, pp. 24-33.

Saqib, M., Farooqui, R. & Lodi, S. 2008. Assessment of Critical Success Factors for Construction Projects in Pakistan. *First International Conference on Construction in Developing Countries (ICCIDC–I) "Advancing and Integrating Construction Education, Research & Practice" August 4-5, 2008, Karachi, Pakistan.* pp. 392–404

Wilkinson, S. 2001. An analysis of the problems faced by project management companies managing construction projects. *Engineering, Construction and Architectural Management.* Vol. 8, No. 3, pp. 160-170.

Wärtsilä Oyj Abp. 2014. Annual report.

APPENDICES

Appendix 1.

EPC PROJECT SURVEY – SUBCONTRACTOR MANAGEMENT

23.2.2015

Asema	**/ Title**	Valitse / Choose
Osasto	**/ Discipline**	Valitse / Choose
Työkokemus	**/ Working experience**	Valitse / Choose v / yrs.

Hyvä vastaaja,

Voit vastata kysymyksiin suomeksi, ruotsiksi tai englanniksi. **Kirjoita vastauksesi täytettäviin kenttiin** (kentän koko kasvaa kirjoitettaessa) tai valitse arvosana osaan kysymyksistä. Anna arvosanaksi yleisarvosana.

Merkitse rasti ruutuun mielestäsi erityisen tärkeisiin kysymyksiin ja vastaa kysymyksiin kattavasti. Muihin kysymyksiin voit vastata lyhemmin, jos haluat.

Tallenna dokumentti ja lähetä se liitteenä osoitteeseen [redacted]. Kysymykset, koskien tutkimuskyselyä voi osoittaa myös samaan osoitteeseen. Kyselyn tulokset julkaistaan nimettöminä diplomityössä.

Kiitos osallistumisestasi.

Dear respondent,

You may answer in Finnish, Swedish or English. ***Write your answers to fillable forms*** *(The size of the form will increase during writing) or pick-up a grade from drop-down list for part of the questions. Use a general grade.*

Place a mark if you think question is particularly important *and answer it comprehensively. Other questions could be answered briefly.*

Save the document and send it as an attachment to [redacted]*. Questions regarding the survey may be sent to the same address. The results will be published anonymously in the author's master's thesis.*

Thank you for your participation.

Merkitse tärkeäksi! / Mark if important!

Q1 Aliurakoitsijoiden ohjaus yleisesti / Subcontractor management in general

Q1.1. Joutuuko Wärtsilä ottamaan usein vastuun aliurakoitsijoiden ohjaamisesta? ☐
Does Wärtsilä often end up to take responsibility for managing subcontractor?
Kirjoita vastauksesi tähän / Write your answer here

Q1.2. Mitkä asiat johtavat edellä mainittuun tilanteeseen? ☐
Which matters cause above-mentioned situation?
Kirjoita vastauksesi tähän / Write your answer here

Q1.3. Millaisia haasteita aliurakoitsijoiden ohjaamiseen liittyy? ☐
What kind of challenges are involved in subcontractor management?
Kirjoita vastauksesi tähän / Write your answer here

Q1.4. Aiheuttaako sopimusten tulkinta ja puuttuminen ristiriitoja? ☐
Does interpreting contracts and lack of contracts cause conflicts?
Kirjoita vastauksesi tähän / Write your answer here

Q1.5. Tarvitseeko Wärtsilän antaa ohjeet aliurakoitsijoiden hallintaan ja ohjaukseen työmaalla? ☐
Does Wärtsilä need to give instructions for subcontractor management in a construction site?
Kirjoita vastauksesi tähän / Write your answer here

Q1.6. Millaiset valmiudet Wärtsilällä on ottaa vastuu aliurakoitsijoiden ohjauksesta? ☐
How well Wärtsilä is ready to take responsibility for subcontractor management?
Valitse / Choose 0 - 5

Q2 Päivittäiset sopimukset / Daily agreements

Q2.1. Tehdäänkö sopimukset aliurakoitsijoiden kanssa riittävässä yhteisymmärryksessä? ☐
Are daily contracts made with sufficient mutual understanding between both sides?
Kirjoita vastauksesi tähän / Write your answer here

Q2.2. Miten parantaisit sopimuksia? Mitä tarkentaisit niissä? ☐
What kind definitions would you make to improve daily agreements?
Kirjoita vastauksesi tähän / Write your answer here

Q2.3. Mitkä asiat sopimuksissa aiheuttavat eniten epäselvyyksiä aliurakoitsijoiden kanssa? ☐
Which matters are the most confusing in agreements with subcontractors?
Kirjoita vastauksesi tähän / Write your answer here

Q2.4. Ovatko aliurakoitsijoiden vastuualueet rajattu selkeästi sopimuksissa? ☐
Are areas of responsibility limited clearly in the agreements?
Kirjoita vastauksesi tähän / Write your answer here

Q2.5. Kuinka hyvin sopimusten sisältöä noudatetaan? ☐
How well content of agreements is followed?
Valitse / Choose 0 - 5

Q2.6. Kuinka hyvin sovitut budjetit aliurakoitsijoiden kanssa pitävät? ☐
How well agreed budgets with subcontractors hold up?
Valitse / Choose 0 - 5

Q3 Työmaalogistiikka ja paikallinen hankinta / Site logistics and local purchasing

Q3.1. Onko aliurakoitsijoilla työmaalogistiikan suunnitelmaa? ☐
Does subcontractors have a construction logistics plan?
Kirjoita vastauksesi tähän / Write your answer here

Q3.2. Mitä työmaalogistiikan suunnitelman olisi tärkeä sisältää? ☐
What should be the main contents of construction logistics plan for site?
Kirjoita vastauksesi tähän / Write your answer here

Q3.3. Onko aliurakoitsijoiden toimittama materiaali sidottu hankinta-aikatauluun? ☐
Are materials supplied by subcontractor tied to purchasing schedule?

Kirjoita vastauksesi tähän / Write your answer here

Q3.4. Mitä tietoja aliurakoitsijoiden valmistamista/toimittamista materiaaleista on tiedossa etukäteen? ☐

What information is available in advance from materials produced/supplied by subcontractor?

Kirjoita vastauksesi tähän / Write your answer here

Q3.5. Kuinka hyvin aliurakoitsijat suoriutuvat materiaalin laaduntarkastuksesta? ☐

How well subcontractors performs in material quality inspection?

Valitse / Choose 0 - 5

Q3.6. Pitäisikö aliurakoitsijoiden valmistamien/toimittamien materiaalien laadunhallintaan puuttua tarkemmin? Miten? ☐

Should there be more control in quality management for material produced/supplied by subcontractor? How that should be done?

Kirjoita vastauksesi tähän / Write your answer here

Q3.7. Millaisia ongelmia rakentamiseen liittyvät muutokset aiheuttavat työmaalogistiikkaan ja hankintaan? ☐

What kind of problems amendment works cause to site logistics and purchasing?

Kirjoita vastauksesi tähän / Write your answer here

Q3.8. Käyttävätkö aliurakoitsijat seuraavien tasojen aliurakoitsijoita vai onko ns. ”ketjuttaminen” kielletty sopimuksilla? ☐

Does subcontractors use second tier subcontractors or sub-suppliers? Is this prohibited in contracts?

Kirjoita vastauksesi tähän / Write your answer here

Q4 Aikataulutus / Scheduling

Q4.1. Projektin pääaikataulun tehtävänä on ohjata projektin kulkua. Kuinka hyvin pääaikataulu ohjaa projektin kulkua? ☐

Main task for the master schedule is to control the project flow. How well the master schedule controls the project flow?

Valitse / Choose 0 - 5

Q4.2. Päivitetäänkö aikataulua säännöllisesti? ☐

Is the schedule updated regularly?

Kirjoita vastauksesi tähän / Write your answer here

Q4.3. Sovitaanko aikatauluista ja sen muutoksista yhdessä aliurakoitsijan kanssa? ☐

Is the schedule and amendments agreed jointly with subcontractor?

Kirjoita vastauksesi tähän / Write your answer here

Q4.4. Mikä on mielestäsi aliurakoitsijoiden rooli työmaan töiden aikataulutuksessa? ☐

What in your opinion is subcontractor’s role in scheduling?

Kirjoita vastauksesi tähän / Write your answer here

Q4.5. Antavatko aliurakoitsijat realistista tietoa edistymisestä? ☐

Is the progress realistic given by subcontractors?

Kirjoita vastauksesi tähän / Write your answer here

Q4.6. Tekevätkö aliurakoitsijat omia, pääaikataulun kanssa ristiriidassa olevia aikatauluja? ☐

Are subcontractors making their own schedules in conflict with master schedule?

Kirjoita vastauksesi tähän / Write your answer here

Q4.7. Helpottavatko hyvät suhteet aliurakoitsijan kanssa aikataulujen tekemistä? ☐

Is it easier to make scheduling with subcontractor with good relations established?
Kirjoita vastauksesi tähän / Write your answer here

Q4.8. Miten parantaisit aikataulutuksen sujuvuutta osapuolten välillä? ☐
How would you improve fluency of scheduling between both sides?
Kirjoita vastauksesi tähän / Write your answer here

Q4.9. Kuinka hyvin sovitut aikataulut aliurakoitsijoiden kanssa pitävät? ☐
How well agreed schedules with subcontractors hold up?
Valitse / Choose 0 - 5

Q5 Kommunikaatio / Communication

Q5.1. Pitäisikö aliurakoitsijan johtaminen sujua sovittujen kokousaikataulujen kautta vai pidettäisiinkö kokouksia tarpeen mukaan? ☐
Should meeting schedule be enough for managing subcontractor or would it be better to keep meetings at need?
Kirjoita vastauksesi tähän / Write your answer here

Q5.2. Miten parantaisit kommunikaatio kanavia? ☐
How would you improve communications channels?
Kirjoita vastauksesi tähän / Write your answer here

Q5.3. Esiintyykö projekteissa epävirallisia sopimuksia Wärtsilän ja aliurakoitsijoiden välillä? ☐
Does unofficial agreements appear between Wärtsilä and subcontractors?
Kirjoita vastauksesi tähän / Write your answer here

Q5.4. Kuinka hyvin kielimuurin aiheuttamista ongelmista selvitään? ☐
How well language barrier is dealt with?
Valitse / Choose 0 - 5

Appendix 2.

12:00 – 14:30 Vantaa 13.3.2015

Asiantuntijahaastattatelu

diplomityöhön:

Developing construction site operations for EPC power plant projects

Mika Nykänen

AGENDA

1) Osallistujien esittäytyminen
2) Diplomityön aiheen esittely
3) Keskustelua diplomityön tavoitteista
4) Tavoitteet haastattelulle
    a. Etsiä parhaita käytäntöjä muista, kuin Wärtsilän projekteista
    b. Löytää uusia suuntaviivoja ja kehityskohtia diplomityölle
    c. Parantaa kokonaiskuvaa projektirakentamisen luonteesta
5) Haastateltavien taustatiedot
6) Haastattelun aloitus
    a. Vapaa keskustelu, ohjaaminen mm. seuraavilla aihealueilla:
        i. Vastuut projekteissa (urakoitsija <> aliurakoitsija, sopimukset jne.)
        ii. Aliurakoitsijan ohjaus / johtaminen työmaalla
        iii. Työmaan materiaalin hallinta
        iv. Töiden aikataulutus aliurakoitsijan kanssa ja raportointi
7) Yhteenveto haastattelusta ja sen läpikäynti
8) Sopiminen haastattelutietojen käytöstä.

… (Haastattelun jälkeen)

1) Haastattelutietojen tarkistus ja koonti
2) Haastattelutietojen lähettäminen haastateltaville
3) Korjaukset ja lisäykset haastattelutietoihin