UNIVERSITY OF VAASA

FACULTY OF TECHNOLOGY

INDUSTRIAL MANAGEMENT

Jussi Viljanen

IMPLEMENTATION OF CONTINUOUS IMPROVEMENT PROCESS

CASE: ETS-LINDGREN OY

Master's Thesis in
Industrial Management

VAASA 2015

TABLE OF CONTENTS

ABBREVIATIONS

BOM	Bill of Materials
C&A	Corporate and Administrative
CBA	Cost calculation Based on the Activities
CI	Continuous Improvement
EMC	Electromagnetic Compatibility
EMF	Microwave and Wireless Testing
ERP	Enterprise resource planning
ETC	Estimate to Completion
ISO	International Organization of Standardization
KO	Kick-off
KPI	Key Performance Indicator
MRI	Magnetic Resonance Imaging
NPV	Net Present Value
OPI	Organization Performance Index
PDCA	Plan, Do, Check, Act
PERT	Program Evaluation and Review Technique
PSI	Process Sustainability Index
RCA	Root Cause Analysis
RF	Radio Frequency
ROI	Return on Investment
SME	Small and medium-sized enterprises
TQM	Total Quality Management
TVM	Time Value of Money
WBS	Work breakdown structure

VAASAN YLIOPISTO
Teknillinen tiedekunta
Tekijä: Jussi Viljanen
Tutkielman nimi: Jatkuvan parantamisen prosessin toteutus – Case: ETS-Lindgren
Ohjaaja: Petri Helo
Tutkinto: Kauppatieteiden maisteri
Oppiaine: Tuotantotalous
Aloitusvuosi: 2008
Valmistumisvuosi:2015 **Sivumäärä:71**

TIIVISTELMÄ: Tässä pro gradu tutkielmassa kehitetään jatkuvan parantamisen toteutusprosessi ETS-Lindgren Oy:lle sekä kehitetään menetelmä kehitysideoiden prosessoimiseksi. Kehitystyön taustalla vaikutti yrityksen tarve kehittää järjestelmällinen prosessi kehitysideoiden keräämiseksi sekä niistä muodostettavien kehitysprojektien läpiviemiseksi. Maksimoimalla resurssien käytön tehokkuuden, yritys pyrkii varmistamaan kannattavan toiminnan myös jatkossa, kiihtyvässä globaalissa kilpailutilanteessa. Tutkielman viitekehyksen perustana olivat alan tieteelliset julkaisut sekä kirjallisuus. Valitun ratkaisumallin perusteena käytettiin tieteellisien julkaisujen lisäksi yrityksen avainhenkilöiden kanssa käytyjä haastatteluja.

Tutkielman tavoitteena oli kehittää toteutusprosessi jatkuvan parantamiseen liittyville kehitysehdotuksille. Tavoitteena oli soveltaa kehitettävää mallia myös muihin yrityksen sisäisiin projekteihin kuin ainoastaan jatkuvan parantamiseen liittyviin kehityshankkeisiin. Tavoitteena oli lisäksi kehittää prosessi kehitysideoiden keräämiseksi koko yrityksen organisaation kattavalla prosessilla. Tutkielman yhteydessä kehitettiin lisäksi kehystysprojektien läpiviemistä tukevia kustannusseurantaan sekä projektinhallintaan liittyviä dokumenttipohjia, joiden avulla kehitysprojektien hallinta ja raportointi harmonisoituu.

Tulevaisuudessa olisi mielenkiintoista tutkia, minkälaisia etuja ja mahdollisuuksia voitaisiin saavuttaa ottamalla ETS-Lindgrenissä käyttöön globaali jatkuvan parantamisen prosessi. Tämän avulla eri yksiköt voisivat helpommin hyödyntää yrityksessä jo tehtyjä kehitysprojekteja ja tutkimuksia.

KEYWORDS: Jatkuva parantaminen, tehostaminen, PDSA-kehä, Demingin ympyrä.

UNIVERSITY OF VAASA
Faculty of technology
Author: Jussi Viljanen
Topic of the Master's thesis: Implementation of Continuous Improvement process Case: ETS-Lindgren Oy
Instructor: Petri Helo
Degree: Master of Science in Economics and Business Administration
Major subject: Industrial management
Year of Entering the University: 2008
Year of Completing the Master's thesis: 2015 **Pages:** 71

ABSTRACT: In this study a continuous improvement implementation process and improvement idea's collection process are developed for the case company ETS-Lindgren. The reason behind the study was the company's need to develop a systematic process for collecting improvement ideas and improving project processing. Maximizing their resource capabilities, the company ensures profitable business in future in global competition. The thesis' context and selected solution were based on academic literature, publications and on the interviews of the company's key personnel.

The goal of this thesis was to develop an implementation process for continuous improvement development projects. The process contains clear responsibilities and tools for CI process' implementation. The goal was also to develop a process of collecting improvement ideas from all company employees. In addition, the purpose was to apply the developed model for company's internal projects. Together with the study an improvement project supporting cost control and project management templates were developed. Using standard documents helps the company to harmonize project management and reporting.

In future, it would be interesting to research what kind of advantages and opportunities it is possible to achieve by having a global, continuous improvement process at ETS-Lindgren. This would help different departments to share results and history data of improvement projects and increase productivity in the company.

KEYWORDS: Continuous improvement, efficient processes, PDSA-cycle, Deming cycle.

1. INTRODUCTION

Companies have realized that, in order to compete in global business environment, they are forced to optimize productivity in all areas. Companies must maximize their resource capabilities to manage this challenging competition situation. This is the reason why many companies have created CI (continuous improvement) programs to achieve cost savings and quality improvements. CI programs seek out innovations that can be minor incremental steps but also significant improvements that can change competition environment. (Wagner, Sue Morton & Chris Backhouse, 2010)

1.1. Research Objectives

This Master´s Thesis project was started based on the writer's own interest of Continuous Improvement process combined with the case company's interest to develop continuous improvement process model. The developed CI model will also be used as the process model for internal projects.

The main objective of the thesis is to develop continuous improvement implementation process for ETS-Lindgren Oy.

The thesis has following objectives:

1. To define a method collecting of continuous improvement ideas and processing for the case company.
2. To develop a model of continuous improvement implementation for the case company.

1.2. Company Profile

ETS-Lindgren is the global manufacturing company focusing different kind of electromagnetic shielding purposes. Part of company´s end products are used for industry purposes e.g. telecommunication and military industry and other part is focused healthy related solution. Company also can provide wide range of complete test systems for different testing purposes. Company has offices in many different country and that help maintain great communication between different market areas. (ETS-Lindgren, 2015)

ETS-Lindgren´s headquarter is located in Cedar Park, USA where company´s largest factory is located. Other factories are in China, UK and Finland. ESCO Technologies is ETS-Lindgren´s main owner that is listed in New York Stock Exchange. (ETS-Lindgren, 2015)

ETS-Lindgren has a factory in Eura in Finland and the company has approximately 70 employees, 40 of those are working on the shop floor. The company's European headquarters is in Munich, Germany. The Finnish factory delivers products and projects to EMEA region and most of the projects are outside Finland. The Eura factory manufactures shielded doors, panels, feed through pipes and air-condition feed troughs. RF-filters those are needed on shielded chambers, are manufactured in the UK.

1.3. Problem Analysis

The company has faced difficulties in collecting and implementing continuous improvement ideas. The process flow is not systematic and improvements don't follow common process flow and this may cause unclear situations where different activities are performed. Unclear roles and responsibilities in CI activities are slowing improvement activities through put time. To achieve full advantage of global supply chain and to utilize USA and China factories some parts cost advantages, company needs an efficient CI process in order to work.

1.4. Structure of the study

In **Chapter 1** background and goals of the thesis are presented. This chapter gives background information for CI importance. Also, the case company is presented and the problem is described.

Chapter 2: This chapter gives theoretical perspective for evaluation of CI ideas. CI activity is described as well as history in general level. Also, using value stream analysis in CI evaluation is described. The chapter goes further on representing company performance evaluation model that is used for CI project objectives identification.

Chapter 3: In this chapter theory of PDSA model is described. This model is applied for ETS-Lindgren CI implementation process. This chapter presents the used model on detailed level and underlines the most critical phases of CI implementation process.

Chapter 4: This chapter introduces the developed CI implementation process for ETS-Lindgren. Furthermore, the templates, which are created to support CI project documentation and implementation, are presented.

Chapter 5: In this chapter conclusion and summary are drawn on the basis of theoretical framework. This chapter also presents future research topics.

2. CONTINUOUS IMPROVEMENT POSSIBILITIES EVALUATION

Continuous Improvement (CI) started in the middle of 1950s in Japan where local companies started to concentrate on business and manufacturing processes instead of concentrating only on results. The basic idea was to create organization culture where everyone in the organization is improving every stage of the process. Western companies started to implement continuous improvement thinking in the early 1980s. (Bhuiyan & Baghel, 2005)

There are many different definitions for CI and Deming described CI as improvement initiatives that increase successes and reduce failures. Bhuiyan and Baghel (2005: 761) define CI quite general way in their article. They think of CI as the culture of sustained improvement targeted to eliminate waste in all systems and processes. Every employee should be involved to CI processes and significant improvement can be done in many cases without capital investments. CI can increase profitability with incremental steps when the working method is changed with small changes, but when an organization can implement new technology or innovation, profitability increase may be remarkable. CI process usually uses many different techniques when the company is trying to optimize material usage and minimize waste. (Bhuiyan & Baghel, 2005)

During the last few decades CI methodologies have evolved together with quality and process improvement management systems. Widely known six sigma, the balanced scorecard, lean manufacturing are the most important management systems that have developed CI methodologies. Even though all these programs are effective for minimizing waste and increasing productivity, the problem is that individual management systems can’t solve all issues. Many companies have combined these management systems together as a combined

CI program. This approach can help companies to solve issues that are difficult to solve using individual management systems. Bhuiyan and Baghel (2005: 773–774) emphasize in their article that Lean six sigma is the most effective hybrid methodology. Lean six sigma combines statistical approach from six sigma methodology and waste optimization high quality from lean manufacturing. Some companies' use lean manufacturing and six sigma parallel, instead of integrating these to lean six sigma methodologies. This isn't an optimal solution and improvement rate will be slower compared to lean six sigma methodologies. (Bhuiyan & Baghel, 2005)

During the last decades, CI has changed from manufacturing focused system to a systematic methodology that integrates all levels of organization from top management to the shop floor employees. For effective CI system, company should work at three different organization levels. At the top level, implications of CI are defined on the organization's strategy. Middle level of organization CI requires problem solving competence at the wide level. At the individual level, CI deals with daily problems. Mandatory for successful CI system is that the company managers should implement CI activities for all these three levels. Managers should assess different process choices, different product designs and layouts, stock levels and product standardizations levels. (Bhuiyan & Baghel, 2005)

CI process has become common management system in companies all over the world. One main reason is that many famous management philosophies includes CI concept like TQM (Total Quality Management), ISO9000 (International Organization of Standardization) and six sigma. Different philosophies have different points of view about problems and it's important to approach problems in many different aspects. For the company, it is important to evaluate the current situation of CI activities in the company and what would be the most crucial areas to concentrate and improve. Cheng, Wang and Xie (2006: 116–118) have developed a methodology for CI activities evaluation. Their model is based on 34 questions that they have sent to 586 companies all over the world. Questions are categorized into six different groups based on the characteristics of these questions. These different questions reflect aspects of continuous improvement activities. They also use correlation analysis for the validity selections and to view interrelations between variables. (Yanjiang Cheng, Yiqin Wang, Lang Xie 2006)

Cheng, Wang and Xie suggest (2006: 119) based their research and findings on that companies should increase support from managers. Managers should increase their support with CI process and make sure that there are enough resources available for CI activities. Cheng, Wang and Xie (2006: 119) also emphasize the importance of CI process evaluation. Every company should have an evaluation process for CI activities. The evaluation process should include indications that the company is frequently measuring. That will give great motivation for employees and CI teams.

Companies should have suitable organizational structure for CI implementation. In practice, this means that organization structure should make it possible to promote rewards, innovations and improvements. It should also create innovative atmosphere that will make it possible to find new ideas and innovations. Cheng, Wang and Xie also analyzed feedback from vendors and customers. Based on their analysis, companies should pay attention to customer feedback. That information has been detected to be useful in finding new innovations and improvements. (Yanjiang Cheng, Yiqin Wang, Lang Xie 2006)

2.1. Value streams modelling for identifying improvement opportunities

New improvement opportunities assessment is a difficult task for the company. Cruz Machado and José Tavares (2007) have researched this problem and they have developed a methodology for value stream modelling. The model where value streams are used for management purposes, built up for assessing company's capacity. The purpose of this model is to help industrial companies' decision making process. The model is based on the idea that services and products flow continually through organizations like value streams. Machado's and Tavares's (2007) have built the model that put together a different indicators those can be used to evaluate level of achievement compared to company strategic objectives those have been established before.

Machado and Tavares' (2007) model is based on two different definitions for integrated performance indicators. Their model contains Process Sustainability Index and Organization Performance Index. Both of these indicators can be used for analysis where existing value streams are evaluated and also company organization performance is monitored.

Processes include activities that add product value and also activities that don't increase product value. Both of these phases are mandatory for complete product manufacturing. This concept looks simple, but in practice, these processes may contain hundreds of sub-processes and this increases the complexity of the process. Every process includes results that can be measured and also add value for internal or external customers. These processes are organization management processes and although these include technical lower level processes. In many cases, the processes are integrated in different levels and those can express e.g. product family or business area. (Machado, Tavares 2007)

Functional management differs a lot from managing by process based value streams. Managing by process based value streams allow company to create management system that is focused and can perform examination to enable value streams controlling with important benefits for the organization. Studies and investigations are needed to define how different processes would be managed and how organizations should be redesigned.

Managing different processes requires specific studies and research how new organizations should be redesigned. (Machado, Tavares 2007)

2.2. Company performance evaluation model

Cruz, Machado and José Tavares (2007) developed a model for company performance evaluation. This model evaluates every activity those have contact to different processes.

Company's success is possible to measure by using results those have achieved in process implementation with added value.

The organization can be thought like system that has connection between environment that is part of the organization. Internal capacity and different external factors create organization performance. Figure 1 shows this evaluation process flow in more detail.

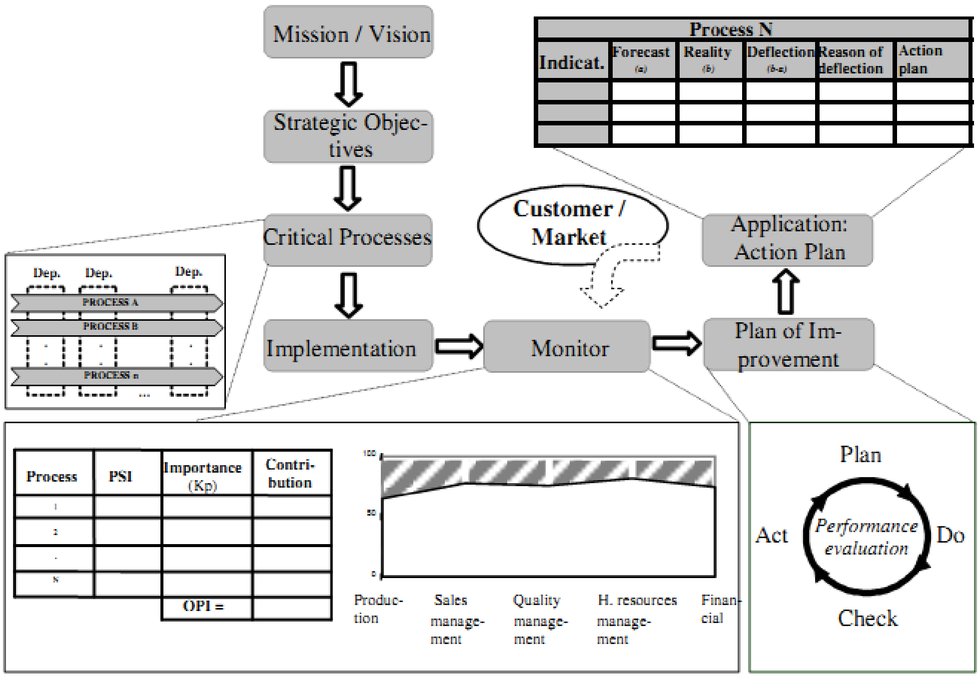

Figure 1: The model cycle operation. (Cruz, Machado & Tavares 2007)

In the study, Cruz (2007) mentions that a company can have more external factors like customers, suppliers, social environment, regulation and competition. Company usually has good communication between employees and also with external parties, whose goal is to increase profit for company´s investments.

It's important to clarify all the company´s external and internal parties to achieve and develop the performance evaluation model.

Performance evaluation model contains five steps. The target of the first step is to identify company critical processes. The second step target is to implement company´s management. The third step of the model is the process monitoring system implementation. The fourth step defines improvement plan development. The last step is to implement and also control created action scheme. This model is described in Figure 1. (Cruz 2007)

Critical processes identification should be done by multidiscipline team. The organization´s strategic objectives are one of the team´s main targets to find. According to Cruz (2007: 362–364), there are many critical factors that should be considered when critical processes are identified e.g. importance of reaching mission goal, major items of success of business and measurable and possible to integrate the business plan. For every identified key process, new indexes will be set and those indexes are used for performance evaluation. In future, this index is used as a reference and the management will evaluate index changes after different time periods. The performance indexes are in line comparing with the company's goals and indexes monitories individual employees those are working with different processes.

Performance indicator varies between different companies. Performance indicator should depend on the company's life cycle. Start-up company's key processes will be different than the company's that is in a mature phase.

Table 1 shows expressions for every indicator. The indicators are analyzed with two different methods. The first method makes a comparison between achievement and estimation. The other method concerns the tendency of performance indicator. It makes a comparison against former monitoring period and evaluation gives a good picture of long term success of improvements. (Cruz 2007)

	Type of reading	Characteristics	Formula
Indicator	Action	Achievement vs. Estimate	X_i = (Real/Prevision)
	Tendency	Evolution vs. Previous Period	$Y_i = N / (N-1)$

Table 1: Performance indicator evaluation. (Crux 2007)

Cruz (2007) introduces CBA (Cost calculation Based on the Activities) analysis tool that is used to increase reliability of performance evaluation model. CBA analysis includes all important definitions for the product. These are sell price for the customer, updated products design and product variation. This tool can also be used for strategic level decision making, as well as the support activities' identifications.

If performance monitoring results aren't in line with goals and implementation degree, the offset is important to measure and reason for this must be defined. Cruz (2007) recommends using PDCA (plan, do, check, act) cycle to create action plan for the organization to achieve the established objectives.

2.3. Global and integrated performance analysis

Cruz (2007) defines two different indexes for performance evaluation. Indexes are used for a global performance evaluation and integrated performance evaluation. The first index concentrates on the process capacity and this is defined as PSI (Process Sustainability Index). This index is calculated for every process and the target is defining achieved performance rate. Assumption in PSI is that the process contains of groups of different activities. Many tasks are performed with strict guidance of different competence segments. This assumption means that all the departments have to develop their working methods and to take into account the company's global objectives and targets. (Cruz 2007)

Every performance index is combined with coefficient K_i that is weighted. The value of this coefficient is between $0<K_i\leq 1$ and this value set the importance of this performance index in the global objectives development process. Expression 1 shows formula for PSI calculation when the Performance indication is below the objective. Expression 2 is used for PSI calculation when the performance indicator is above the objective. (Cruz 2007)

$$PSI = \left(\frac{\mathrm{Re}\,al_A}{Forecast_A} \right) \times K_{iA} \times 100 \qquad (1)$$

$$PSI = \left[\ 1 + \left(1 - \frac{\mathrm{Re}\,al_A}{Forecast_A} \right)\ \right] \times K_{iA} \times 100 \qquad (2)$$

The next index is associated organization global performance. That is defined as OPI (Organization Performance Index). OPI calculations use the same method as PSI for each process to define individual process coefficient of pond ratio (K_p). Ideal result for OPI and PSI indicator is as close to 100% as possible. (Cruz 2007)

3. Continuous Improvement implementation process

The execution of continuous improvement is often challenging for many companies. Artsengel and Kurtogl (2013) have developed systematic method for continuous improvement implementation at operation level. Their method provides an entire methodology for undertaking process improvement projects or operations activities. Project approach has been an effective method for CI activities and it has focused on results and the means to achieve those results. Every project has a beginning, middle and an end. Every succeeded project has had an impact on the process and the situation has improved since the beginning.

3.1. The PDSA model

PDSA Cycle is used for all process improvement projects. PDSA model is a simple approach and it supports rapid cycles of improvement. This model is widely used in health care sector and it has been an effective and powerful tool for learning. PDSA cycles are usually small scale tests to try out ideas for improvement. Figure 2 shows PDSA model that contains five key phases: initiate, plan, do, study and act. All these process groups have clear dependencies and all phases proceed with the same sequence on each "process improvement" project. (Tim Kotnour 2000)

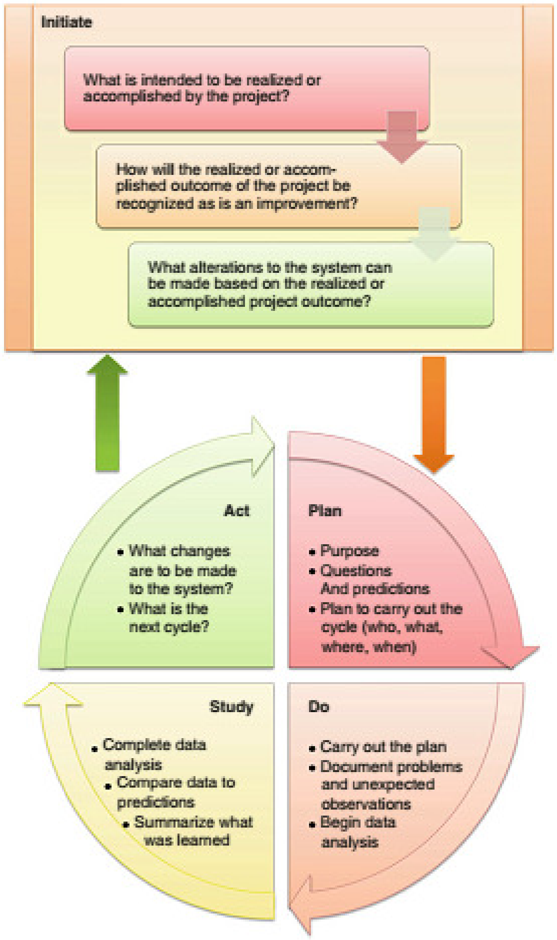

Figure 2. PDSA cycle for Continuous improvements (Aartsengel and Kurtogl 2013).

PDSA model is used as a framework for application of competence, skills, tools and techniques to "process improvement" project to fulfill CI project demands. (Tim Kotnour 2000)

3.2. PDSA model initial phase

Initial phase is the first phase in the "process improvement" project's management life cycle. In the initial phase, the project manager sets the purpose, goal and the constraints for CI project. It's also important to clarify how the project's success can be recognized and changes in the improved process will be made to the company's systems. During the initial phase, the project manager should establish project management controls. According to Aartsengel and Kurtogl (2013) an important target is to get to an agreement on which people and business functions are involved in the project and how much time they can spend on this project.

During the initial phase, the project manager identifies all stakeholders. It's easy to identify people and functions that are directly affected but identifying the secondary stakeholders is usually difficult. One widely used technique to identify stakeholders is brainstorming. Internal stakeholders are individuals within the company business who use information and deliverables of project. External customers are consumers who pay for the project outcomes. (Snyder 2013)

Stakeholders have different levels of interest for CI projects. Stakeholders that agree that a CI project will benefit them after the project is done, usually support and help the CI team. In some cases, legislators and policy makers are concerned that the company is wasting public money by funding unprofitable CI project. Figure 3 describes that stakeholders can be divided into different groups, based on their interest level and influence level. (Aartsengel and Kurtogl 2013)

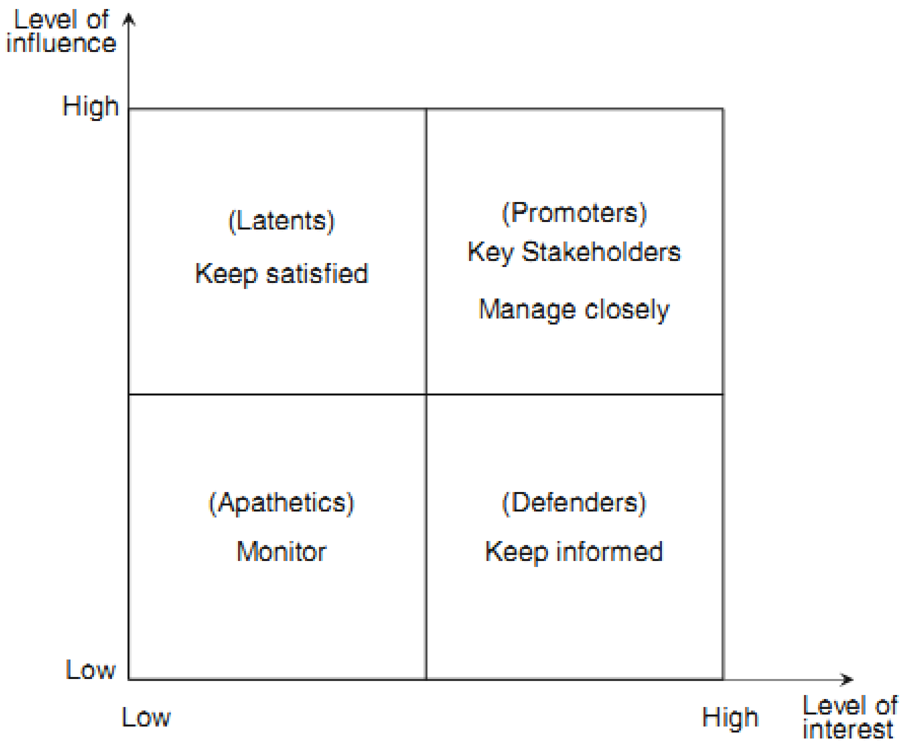

Figure 3. Stakeholder categorizing. (Aartsengel and Kurtogl 2013)

There are also other techniques for stakeholder analysis. Jia, Jiaoju and Qiang (2012) have used eight categories for stakeholder evaluation. These categories describe stakeholder attributes and stakeholders who possess most of these attributes should be the most active and pursue their own interest. Growing realization about stakeholders' identification importance and their impact to success of a firm, leads naturally to the development of stakeholder analysis. It's important to find out stakeholders influence, interest and also their affect to the company performance. (Jia, Jiaoju, Qiang 2012)

Project background and purpose is important to define at initial phase. The project should have one goal and a clear description what is intended to accomplish by the CI project. Project success criteria are used for evaluation of achievements. Aartsengel and Kurtogl (2013) mention three different success criteria: Increased revenue, reduced costs and improved product. The best option for success criteria is to state clearly the impact of the project on the company's business intended strategy.

When the initiation phase is complete, it's important to perform a review for the project's objectives and check that all necessary elements are there. The review should be completed with a formal request approval to proceed to the next phase. The project manager's task is to present project status to the project board that grant the approval to proceed to the next phase, undertake further work with initiation phase or cancel the CI project. The project review group includes members from the company and in some cases also from a third-party. The review group ensures that all business risks are identified and the project goal and vision is reliable. (Aartsengel and Kurtogl 2013)

3.3. PDSA model planning phase

The planning phase consists of detailed description and planning of how CI project will be performed. The planning phase defines how project's goals are possible to obtain and what the constraints are. During the planning phase, it is important that stakeholders and customers understand underlying objectives and the most important requirements. If project requirements are not clear, it will be a difficult task for project manager to set up the project plan. (Snyder 2013)

The project manager develops during this phase the Project Management Plan. This plan documents all actions that are necessary to define, prepare and integrate, and coordinates all lower level plans into project management plan.

The plan documents all key elements, deliverables and objects of the CI project. According to Aartsengel and Kurtogl (2013) there are three major advantages to developing a robust process improvement plan. The first advantage is reducing uncertainty through following the detailed project plan even though everything doesn't always go as planned. The process improvement plan also increases the understanding and learning of the project team about the goals and the objectives. After the process improvement plan is ready and all necessary resources are defined, schedule for CI project can be done. In many cases it’s possible to work simultaneously to improve efficiency. Using parallel working method, the project team can cut the total duration of the project and maximize resource usage.

3.3.1. Work Breakdown structure

WBS (Work breakdown structure) divides project task smaller sub-tasks. These small sub-tasks are easier to control and manage comparing large entities.

Tasks that aren´t introduced in WBS might be removed from project content. Breaking the project into sub-tasks, will help the company employees to solve complex problems and the project schedule tracking becomes easier for the project manager. (Zhang, Deng & Zou 2009)

Figure 4 shows WBS model where different activities are divided into smaller, more manageable components. The lowest level activities are the work packages and at this level cost and time schedule can be reliably estimated. Decomposition of the total project into work packages requires identifying and analyzing the deliverables and also structuring the organizing WBS. It’s important to verify the degree of decomposition of the work if needed. According to Aartsengel and Kurtogl (2013) there is no unique WBS that is suitable for every project but it's important to use the same WBS principles to ensure that working packages are of manageable size.

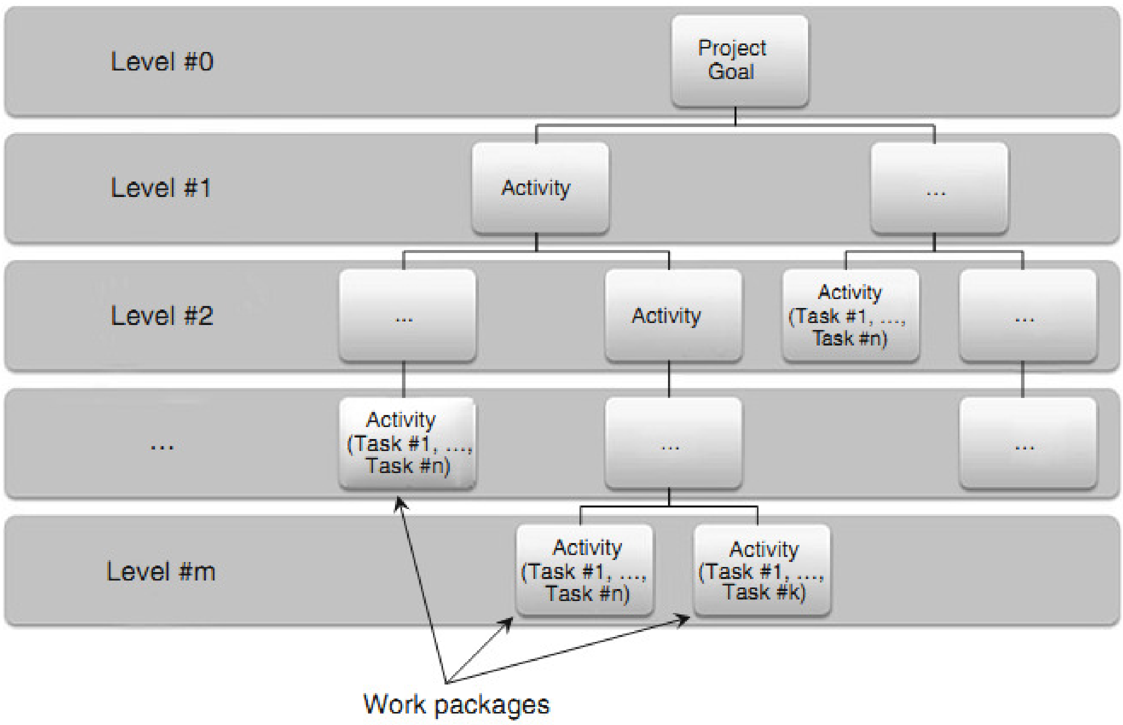

Figure 4. Work breakdown structure. (Aartsengel and Kurtogl 2013)

WPS can be used as a thought process tool when it's easy for the project members to visualize how project work can be set and handled proper way. It also provides a view about the total work of the project and what are the interconnections between different tasks. During the planning phase, WBS gives a detailed picture of CI project and a set of tasks that must be finalized to finish the project. (Aartsengel and Kurtogl 2013)

3.3.2. Project time management plan

To achieve accurate project time schedule, it's necessary to analyze task durations, resource requirements and activity sequences. The project manager needs the estimates of duration of every work package and the resource estimates to develop project's time schedule. Some project activities do not need to be scheduled with the same accuracy and there may be many different schedules for every functions (e.g. manufacturing, design, test solution). In many cases, these individual time schedules are the base of WBS. (Snyder 2013)

There are many different techniques for scheduling. Aartsengel and Kurtogl (2013) suggest using basic approach where event relationships are described graphically and all relations between tasks are defined. This basic technique is an effective tool for planning and controlling the CI project. Network techniques like PERT (Program Evaluation and Review Technique) are the most common approach to project scheduling. Also the use of Gantt Charts is common in many companies. PERT has been used for project scheduling since 1958 but despite its age, it's still widely used. It is a useful tool to identify critical parts of the project and it establishes the earliest and the latest start and finish times and duration. Figure 5 shows an example in flow diagram. Milestones are described as circuits and numbers between the activities express the duration of each task.

3.3.3. Resources Management

Resources are essential for every successful project and according to the study, it's one of the most common reasons why projects fail. In the challenging market situation, it may be challenging to spend a lot of resources on internal projects and that's one important thing that should be clarified at the planning phase. Without the needed resources, it's impossible to complete the project on schedule. The project manager must assess resource competencies and define carefully that all project needs can be defined. (Liu, Xie & Ren 2008)

Resource management plan clarifies all types and amounts of resources that are needed in the project. Resources can be inventories, labor, materials, equipment and suppliers. According to Aartsengel and Kurtogl (2013), labor scheduling and management is the most difficult to manage. The target of labor resource planning is to identify human resources with necessary skills. The labor resource plan should be documented with detailed role description for every resource.

Many internal CI projects need proper facilities for project's individual work packages. In some cases it might be R&D laboratory, conference room or factory time. These needs should be listed to a separate document with a description of the purpose with estimated time frame.

3.3.4. CI Project cost management

Cost management is an important function for every continuous improvement project. In many cases, cost reduction is the driver to create and perform a new project. The cost management plan is a process where the project manager needs to ensure efficient cost tracking and decision making. The project manager's main task is to develop a cost management plan that includes project cost accumulation and cost assignment. Every company has managerial account systems that collect cost data and the project manager's task is to ensure that costs are associated to right cost centers and resources. (Aartsengel and Kurtogl 2013)

During the project's planning phase, it's important to identify different cost types in the project. By identifying these cost types, it's easier to develop accurate cost management plan. Costs can be divided into direct costs and indirect cost based on the cost type. Direct costs are easy to trace and can be pointed to the project without problems. Direct costs are e.g. costs of the materials that are used for this particular project. Also wages and equipment costs of the project team are easy to trace and are a part of direct costs. Indirect costs are difficult to trace and these need to be analyzed in more detailed to achieve accurate cost allocation. These indirect overhead costs are e.g. office rent, office heating and electricity, security service and equipment maintenance costs. Many companies use Activity-Based Costing accounting procedure for allocating overhead expenses and indirect costs. This costing method uses resource usage proportion for cost allocation. All indirect costs are divided into two categories: overhead costs and fringe benefit costs. Overhead costs contain all labor-related costs that create project environment and fringe benefit costs are non-salary and employee-based costs which create different parts that maintains a workforce. These are e.g. enterprise business payments toward employee health insurance, stock options and tuition-aid programs. (Iltuzer, Tas & Gozlu 2007: 1119–1121)

Many companies add additional indirect costs to employee salaries to define total charge-out rate. This method eases the company to allocate overhead costs to project work. The project manager uses this fully-loaded charge-out rate for calculations of the project cost estimation. Expression 3 shows calculation for predetermined overhead rate.

$$Overhead\_Rate = \frac{Estimated\_Total\_Company\_Overhead\_Costs}{Estimated\_Activity\_Base} \qquad (3)$$

This formulation is simpler that calculations usually are but the theory is the same. Many companies aim to minimize indirect costs to achieve more competent business environment.

Project cost data contains different sources. Salary costs can be calculated easily when employees are working directly for the particular project. All additional salary costs are included to the project costs e.g. overtime costs, benefits and training costs. Part of the capital cost is allocated for CI project. Many company assets are not new and those have acquired same cases many years ago. In some cases, these assets have already paid by company but still these have taken account to cost collection. These are called "opportunity costs" because these assets may be used for other activities within the company. The cost amount is based on the current market price of the assets in the same condition that they are at moment when they are used. (Aartsengel and Kurtogl 2013: 271–272)

Overhead costs can be allocated for the project by using two-step method. First, all costs of the C&A (Corporate and Administrative) service should be defined. The second step is to allocate these costs to the projects based on the project's share of total costs. C&A costs include cost of Executive Management, Communications, Personnel, Finance and Informatics. From this cost information simple departmental factor can be calculated and that is used for e.g. personnel costs and project support overhead. (Aartsengel and Kurtogl 2013: 273–274)

Make vs buy analysis is an important tool for evaluation of the most cost effective method. In-house manufacturing may not be the most cost effective method for all sub-parts of the CI project and also delivery schedules are an important factor in make vs buy analysis. Make vs buy analysis takes into account only those costs that will change if in-house manufacturing is used. In the other words, if some cost type remains on the same level regardless of the mode of performance, these costs need not be calculated. The cost comparison should be as fair as possible and e.g. in case of overhead costs, these costs should be carefully identified for this particular case. An important part of the make vs buy analysis is the quality and service level evaluation. In the comparison, quality and service level should be at the same level to ensure proper analysis. (Aartsengel and Kurtogl 2013: 273–274)

Make vs buy analysis covers a long time period even for this particular case, contract is short term. Conversion costs are possible to spread over a reasonable period of time and e.g. in-house manufacturing capital costs may not be planned to occur in short term. The company's cash flow and TVM (Time Value of Money) are also involved in the analysis over time. Received and paid out time frames should be estimated to make the comparison equivalent for both options. According to Aartsengel and Kurtogl (2013), there are four steps for proper costing methodology. The first step is to specify procurement items costs on which cost are assigned. After that, the target is to define all costs for in-house manufacturing and determine costs of procurement. As a final step, cost comparison will be done for these two options and make the final decision.

3.4. PDSA model "Do" phase

"PDSA Do" project phase is the longest process phase in PDSA model. During this phase, physical products are built and those are reviewed with stakeholders. Also problems and challenges are raised during this phase and all these will be documented and analyzed in the next project phase. To document these observations is important for effective "PDSA Study" phase and will improve the company to avoid these problems in future projects. According to Ning, Chen and Liu (2010:62), "Do" phase is not only literally doing tasks. This phase also contains implementation of practical measures, controls the process that enables activities to proceed as expected. This phase contains three different measurements: do, control and regulate.

During this project phase, the project manager must make sure that all activities that are listed, will be implemented within budget, on time and according to the specifications to ensure a successful project. It's important to implement each process and communicate the process clearly to the project team. According to Aartsengel and Kurtogl (2013), many projects globally have faced problems because of lack of formalization of these simple, but critical, project management processes. It's common that alteration has to be made to the project plan. Resource productivities and availabilities may change and also activity durations. All these changes should be analyzed and based on the results the project management plan may have to be modified.

3.4.1. Phase Deliverables

Implementation steps will vary depending on the project type and size, but all projects have similar deliverable elements. When improvement process operates unpredictably, this should be motorized and one method to observe this is to use process behavior charts. In figure 5 the effects of assignable causes in process outcome are illustrated.

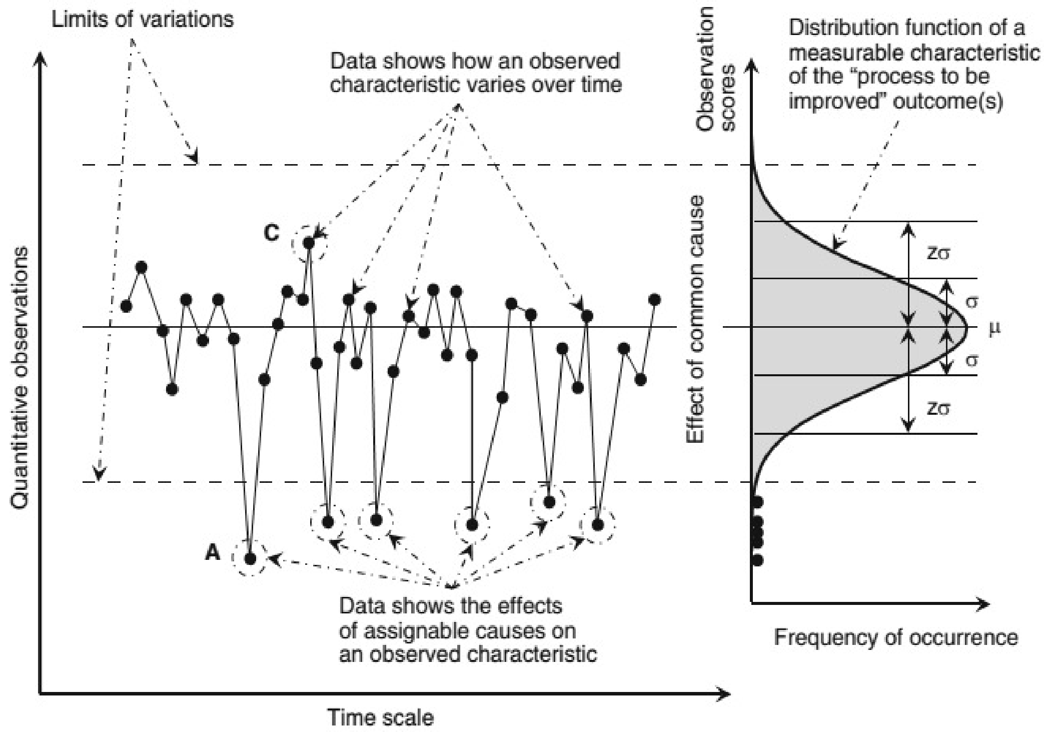

Figure 5. Effects of assignable causes in process outcome over time. (Aartsengel and Kurtogl 2013, 448)

In figure 5, horizontal axel is time and vertical axel is quality performance. The middle horizontal line is the average of past performance and upper and lower lines are statistical limits for performance. Point A and many other points are under lower statistical limit and causes for these deviations should be analyzed. If analyzing is not performed, the results will be of limited validity and dubious utility. Another method for identifying assignable causes of variation is to interview project team to establish boundary conditions of occurrence of assignable causes. The goal is to get physical evidence and to provide detailed information about the event that lead to the occurrence of assignable causes. (Aartsengel and Kurtogl 2013: 447–449)

3.4.2. Process Steps and Tasks analyze

Improvement project consists of many discrete elements that are mandatory for successful CI project implementation. Process steps and task analysis composes analysis for each project discrete element by using the same method. The first step is to identify discrete element goals that ensure success of the particular element. If there is no concern for the element that is under evaluation, there is no need for actions. If concern exists, the next step for the project team is to examine resource-task interaction and the operations underpinning performance of the discrete element.

The project team will consider first the inputs and outputs of the resource-task system that describes what material and information flows elsewhere in the enterprise business and beyond. This information would help the project team to define the importance of the goal of project's success and company's business. After the process of identifying discernment elements, the next step is to assess if the goal can be achieved to an acceptable standard given prevailing circumstances. Also to explore constraints on how responses to inputs to the process discrete element considered are made. It´s important to find and assess constraints because those can limit options, which are adopted and pursued to achieve goals on practical projects. Prevailing circumstances may, in some cases, cause unexpected delays for working schedule. For example, working time or accessibility to the workplace may be limited in some cases and these will cause problems for the project's workflow. The project manager is responsible for performing effort analysis for these discrete elements that are critical for the project and can have this problem. (Aartsengel and Kurtogl 2013: 483–486)

Operation examination step includes resource-task interaction with a view to generation an improvement hypothesis that will eliminate the performance gap.

During this step, the project team tries to eliminate useless discrete process elements and when this can be done, it will help the company to decrease overall costs. In many cases when tasks are eliminated, the implementation cost for that is very small and benefit is the same than full cost of performing that step. The project team also tries to question what the best location and time is to perform a particular process element. According to Aartsengel and Kurtogl (2013), significant benefits have been achieved by questioning current working methods. In many cases that also creates the highest costs because changing the working methods may need new equipment, programming and training.

3.4.3. Solution and prototype generation

At the beginning of generating an improved solution for CI project target, project team must review all data about causes of variation. It´s important to "sell" the new solution to employees to ensure success in process' improvement. One way to help this is to make sure that employees are involved in the process and give their input to the project team. When employees have agreed to the new solution, it will increase acceptance of the current state of the process or product that is the target in the CI project. According to Aartsengel and Kurtogl (2013), one way to increase employee commitment to CI improvement is to involve employees in brainstorming session where envisioning improved process. In many cases employees have answers to the underperformance problems, but they don´t know that. Brainstorming session's main target is to get that information available and document the data.

During the brainstorming session the project manager gets many potential solutions for the problem but many of those might not meet the requirements of business. The project manager decides what the most important potential solutions are for CI project's improvement, but this is a difficult task to do.

Aartsengel and Kurtogl (2013) suggest using prioritization matrix to identify the best solutions. Matrix is described in Figure 6.

Selection Criteria		C_1	C_2	...	C_j	...	C_M	Total
Weights		w_1	w_2	...	w_j	...	w_M	
Potential Solutions	S_1	ρ_{11}			ρ_{1j}			
	S_2							
	...							
	S_i	ρ_{i1}			ρ_{ij}			$\sum_{j=1}^{M} w_j * \rho_{ij}$
	...							
	S_N							

Figure 6. Priorization matrix for solutions identify. (Aartsengel and Kurtogl 2013, 522)

Project team creates selection criteria for the selected solution. Criteria may be e.g. Quality, Cost and ease of implementation and all selected criteria's should reflect project goals. Weight criteria can be determined by using "nominal group technique" where every team member gives weight criteria for every selected criterion from 1 to 5 and calculating relative weights using average values to determine individual weight for every selection criteria. Potential solution strength from selected criteria point of view can be evaluated by using the same method as weight criteria evaluation. The best solutions can be identified by multiplying weights and strengths of every potential solution and the highest total value is the most important solution and the CI team needs to focus on that solution. In many cases, it´s useful to select few potential solutions for more detailed analysis.

Prototype development is an important part of CI project. In some cases, the prototype development doesn´t have any tangibles and in those cases the prototype includes analysis and data. During this phase, the project team will test product/process in real action and perform tests for the prototype. In many cases the project team introduces the new solution for stakeholders, employees, customers and measures their experience. Prototyping and piloting scale should be evaluated case by case. Advantages for large scale piloting are the increased feedback, evidence and data and lower risk for failing project. Small scale piloting helps people to accept the potential new solution and it also gives important feedback from stakeholders to the project team. In some cases there can be many different scales of piloting. At the beginning, the project team tests the new solution by small scale piloting and after this with large scale piloting. Large scale of piloting has higher costs if the new solution fails but also gives deep understanding about the selected solution's cons and pros. (Aartsengel and Kurtogl 2013: 524–527)

3.5. PDSA model study phase

During the study phase, the implementation's effect is evaluated. The analysis concentrates to the whole implementation process from the beginning to the end and during this step, all data and information about implementation will be analyzed. The target is to check the company's management system and implemented product or services. (NingI, ChenI and Liu 2010)

PDSA study phase compares data that has been generated in the planning phase and in the do phase. The analysis concentrates on the business point of view where profit and return of investments are calculated. Also, the achievements of the process' improvement are analyzed. To ensure that all requirements are met, the project manager monitors and controls the qualification, validation and revalidation of every deliverable by executing a suite of planned management processes. After this verification process, a phase review is carried out to make the decision if the project is complete and ready for closure. (NingI, ChenI and Liu 2010)

The purpose of the study phase is to create new knowledge through learning process. The project team's important task is to calculate whether new improved process or solution will result a better outcome. Collecting measurement data and monitoring process performance will help the company's management in the decision making process. This will help to make decisions that are based on objective data instead of political aspects. Performing proper PDSA Study phase includes many discussions between different departments in the company. These discussions are important from the point of view of learning. Discussions' nature should have positive context, focus and integration. Figure 7 shows the minimum activities that are part of the PDSA study phase.

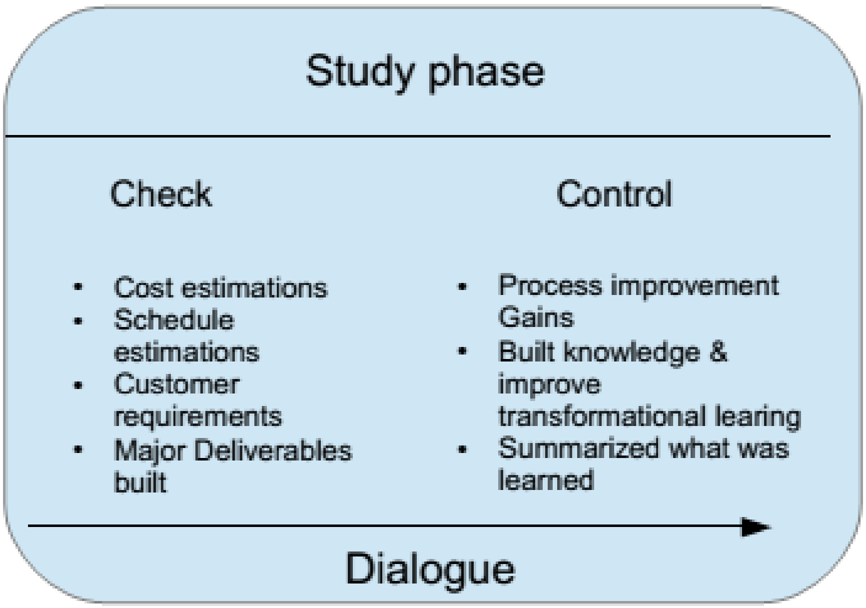

Figure 7. Minimum activities of the PDSA Study phase.

According to Aartsengel and Kurtogl (2013) "Dialogue" is the main driver in continual learning and that is also the basic unit of "process improvement" project work. It´s impossible to plan, execute and learn well from CI project without proper dialogue with customers and stakeholders. Aartsengel and Kurtogl (2013) think that "dialogue" should be understood in the sense of "sharing collective meaning" and strongly differentiated from "discussion".

The main goals of the study phase are to collect retrospective data over time, to compare data to established baselines and to summarize what was learned. The collected data includes Return of Investment calculations that give important information about the CI project's success from the economical point of view. This calculation answers if the project managed to fulfill the business needs and expectations. Every CI project has to enable company's business sustainability and meet the needs of the employees and shareholder. (Aartsengel and Kurtogl 2013: 573–575)

Customer and stakeholder´s needs and fulfilling expectations are important things that should be measured. The degree of satisfaction can be used to evaluate the project's success. Collecting this data gives accurate information to validate and complete the CI project. The project's success can be measured directly by using this data to analyze and validate the process' performance.

There are many different methods to summarize the collected data from the CI project. Widely used graphical methods are e.g. Control Charts, Run charts, Scatter Diagrams and Pareto Charts. It is seen in Figure 8 that before the CI project's implementation, there was significant variation in the test data. There were many samples over upper control limit and also under lower control limit. After prototyping phase, the variation has decreased significantly and all samples are within limitations. (Aartsengel and Kurtogl 2013: 576)

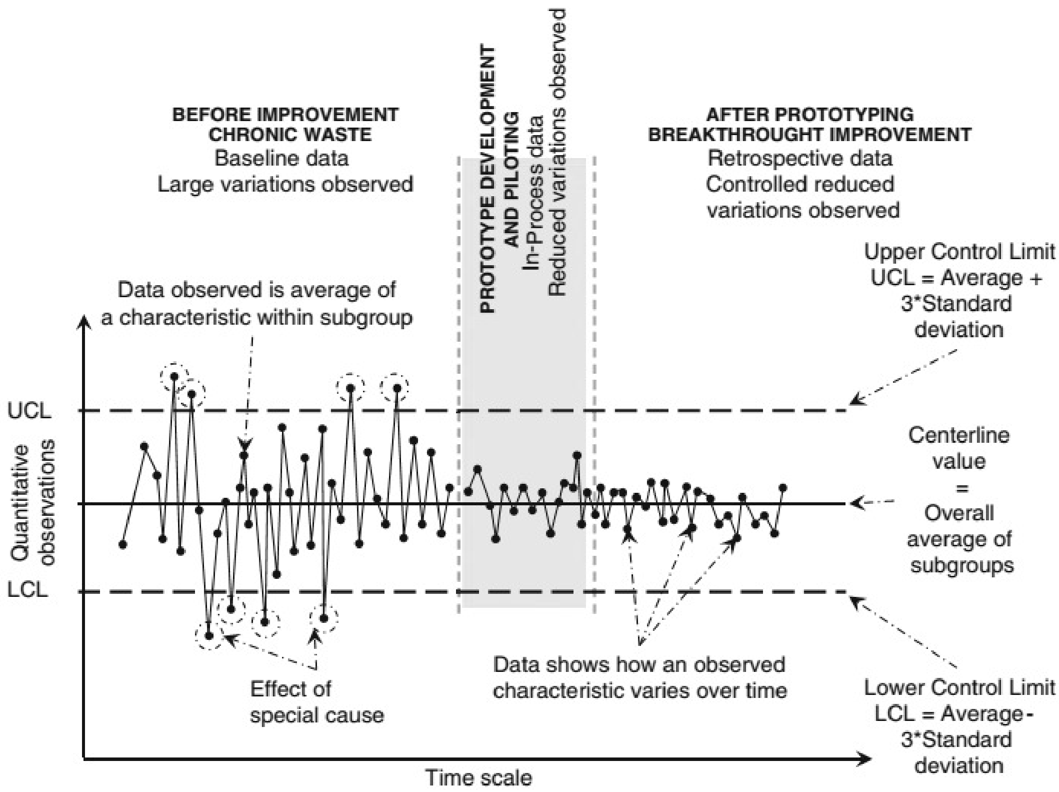

Figure 8. Control chart with example data. (Aartsengel and Kurtogl 2013, 576)

Control cards are widely used to analyze changes in the process' improvement. After analyzing this retrospective data, it´s possible to decide to start a new improvement process or keep the present situation.

3.6. PDSA model act phase

PDSA method's most crucial phase for CI project is "PDSA Act" phase. This phase determines whether the project is succeeded or failed. According to Aartsengel and Kurtogl (2013), this phase is often poorly managed even though this phase should ensure that all developed practices are established. This phase is often the best remembered of all phases during a CI project and the project manager's task is to ensure organized completion of "Act" project phase. The project's conclusion is influenced by the reason for its termination. There are many different reasons for project termination.

The optimal situation is that the CI project ends to an improved solution or process implementation and deliverable's installation. Implementation might involve different phases and cutovers and this new improved process triggers the beginning of a many other activities like documentation, standardization, and report preparation. (NingI, ChenI and Liu 2010)

By end of the "Act phase" all project documentation must be finalized. Documentation is in many cases overlooked and the project manager must give special attention to this task. Documentation consists of e.g. final cost reports and contracts. Aartsengel and Kurtogl (2013) have mentioned a few reasons why the project team needs to do documentation. The most important reason is collecting historical record for future projects. This can be used e.g. for estimation of new CI projects. Historical data can also be used for training purposes for new project managers. WBS, which is described in section 3.3.1, may be useful to help to define new project's architectures. Some companies may use documented information for performance evaluation of the project manager and the project team. In Figure 9 minimum activities are mentioned that must be involved in the "Act phase".

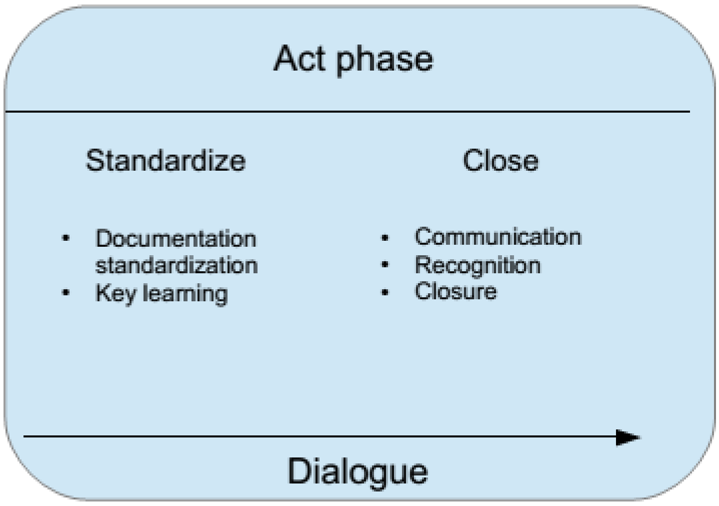

Figure 9 Act phase minimum activities.

After the improved solution has been implemented, new standard policies and practices must be established. In practice, these standard policies and practices mean e.g. that company employees' working methods are the same and employees share information with co-workers of ongoing efforts to improve.

Aartsengel and Kurtogl (2013) suggest that the project manager writes the project's final report to summarize the history of the project and performance evaluation. This task would be the project manager's last task before the project will be terminated. Every company can define the best format for their purposes, but Aartsengel and Kurtogl mention that reports should include a review of the project's objectives, identification of improved performance and comments for overall success, project organization and the project team's recommendations.

4. Empirical Analysis of the Case Company's Continuous Improvement Implementation Process

This chapter concentrates on present developed ETS-Lindgren continuous improvement process flow. This process flow has been developed by interviewing and brainstorming key personnel from different departments and functions of ETS-Lindgren's organization. The selected solutions are also supported by Artsengel and Kurtogl's (2013) published scientific research. In Figure 10 CI ideas' implementation process flow is described. The process flow describes different methods for continuous improvement ideas' collection from each departments and stakeholders. The main goal of this process flow is to collect all valuable improvement ideas from all ETS-Lindgren employees and process these ideas in the right way. This process flow is used for significant improvement projects. Minor work routine modifications are performed without using this process model. This developed process flow won´t be used for new product development projects. The company has a separate process for that kind of projects.

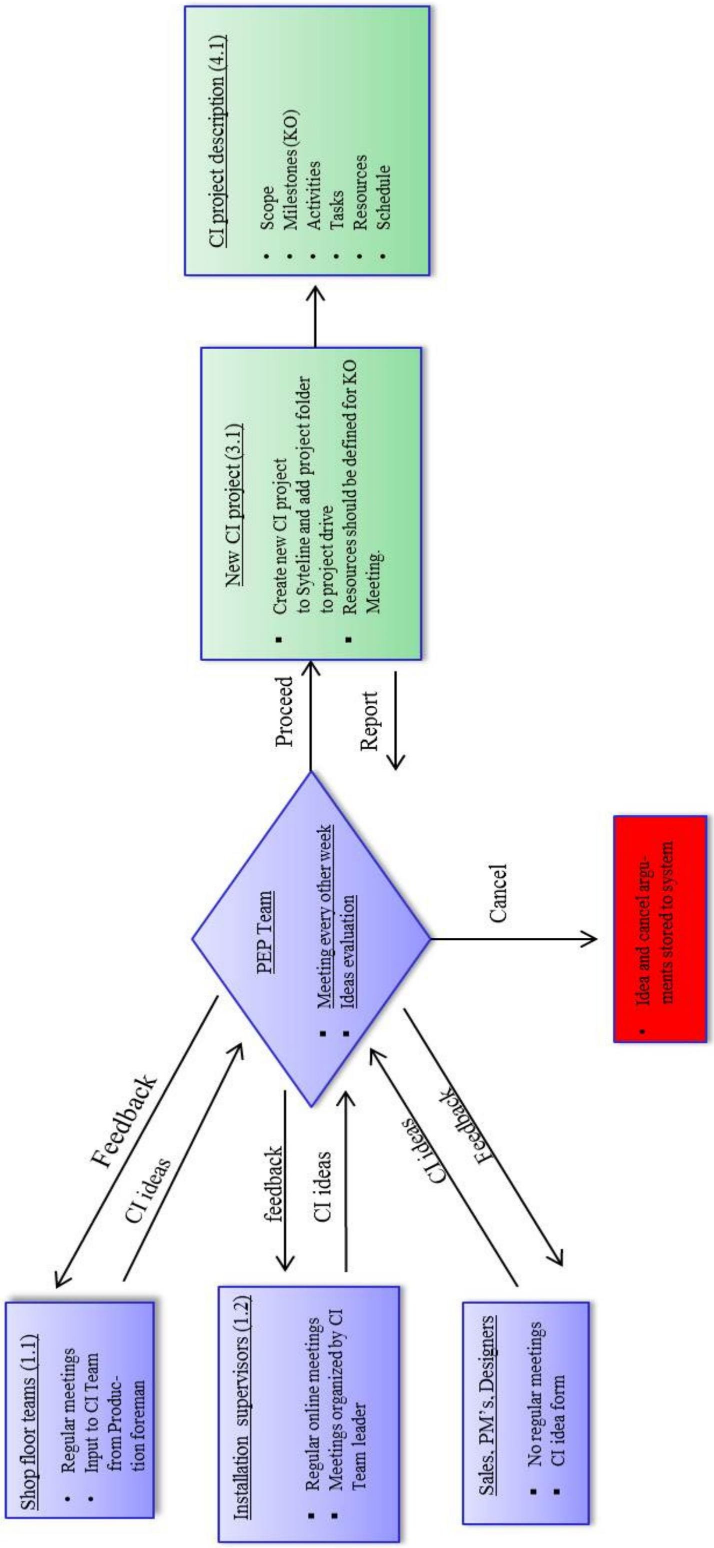

Figure 10: ETS-Lindgren CI implementation process.

Even though this process model is mainly developed for CI implementation purposes, it will also be used for other internal development projects. ETS-Lindgren develops continuously new products to meet new telecommunication industry's standards and needs. This process flow can be used for new products' manufacturing ramp-up and old production line's modifications. These kind of internal projects are very challenging and need a systematic process to be accomplished properly.

ETS-Lindgren has created a PEP-team (Product enhancement process) that concentrates on cost savings by using different methods and solutions. The team has regular meetings every other week. This team consists of members from different departments and countries and has the competence to evaluate a wide range of ideas. This team processes every significant CI idea and makes the decisions to proceed or to discard.

A new project will be created after PEP-team has approved the given CI idea and the project moves to the next phase in the process flow. PDSA project method is described in more detail in chapter 4.3 and the main target for PDSA is to ensure logical and controlled project flow from the beginning to the end of the project.

4.1. Continuous improvement ideas collection

ETS-Lindgren has many experienced professionals working in different departments and positions all over the company. One of the main targets of this thesis was to develop a model for collecting continuous improvement ideas from all company employees and main subcontractors. Because a part of the company's employees and subcontractors are working in different countries, the idea collection method will vary between different stakeholders. It´s very important to have a process for collecting ideas to remove systematic quality, design and shipping errors. Without feedback e.g. from the installation team, it´s is impossible to make corrective actions and prevent repeating the same errors in the future. Every deficiency that is detected on site, causes significant extra costs for the company and has a negative impact on customer project's gross profit. In many cases this also causes project delays and longer installation time.

Many given continuous improvement ideas need actions from different functions and it´s impossible for an individual employee to make these changes. This is one of the reasons why CI ideas' collection process is important. It enables an individual employee to make significant improvement and changes that would be in practice impossible without this process. Having this opportunity motivates all ETS-Lindgren's employees to create and submit ideas.

The company's employees have different backgrounds and various job descriptions. This will lead to a large scale of variation about given continuous improvement ideas. E.g. ideas that are given from the company's top management may more often be based on Value Chain Analysis, which is desribed in chapter 2.2, compairing ideas those are providing by installation supervisor who usually concentrate directly to cost savings by cutting material or installation cost.

4.1.1. CI ideas' collection from the shop floor employees

ETS-Lindgren's shop floor employees are divided into different teams based on the type of the product line. These individual teams work using different methods to find out bottle necks and solutions to cut cycle time or material cost. Every shop floor team uses the same CI idea template and this is shown in appendix 1. Using the same format and adding calculations of preliminary cost saving helps processing CI ideas. CI teams have regular meetings with factory's PEP-team's contact person and go through new ideas before they are submitted to the PEP-team. Using teams to CI activities increases brainstorming effect and helps the shop floor team to find solutions for different problems.

4.1.2. CI ideas' collection from installation supervisors

ETS-Lindgren uses installation supervisors to coordinate installation of shielded chambers and systems. Roughly half of the supervisors work continuously in Finland and the rest work in other countries in Europe. In practice, installation supervisors work all the time on site and that makes collecting CI ideas difficult. Supervisors don't have teams for CI activities, but customer projects' PM collects improvement ideas from supervisors during the project's post mortem meeting. After that, the PM sends idea forms to PEP-team's contact person. This process is new for ETS-Lindgren and it integrates company vendors to the CI process. This feedback is very valuable and helps the company to save costs in future.

4.1.3. CI ideas' collection from other stakeholders

Designers, project managers and sales managers don't have regular CI meetings. Members of these groups can give improvement ideas by using CI templates at ETS-Lindgren intranet site. All company employees have access to the company's intranet by using VPN connection. Local PEP-team's contact person takes care that ideas will be documented and processed. The status of the idea can be checked from CI intranet site. All company employees will be trained to use company CI intranet site.

4.1.4. CI ideas' documentation

All given CI ideas are stored in ETS-Lindgren intranet database. CI site collects all CI ideas and projects to the same easily achievable location. All ideas will be stored to this database and saved for future use. This material is valuable in future and can be used for training purposes or as a new project template. The main document that is shown in appendix 2 consists of information about what the status of idea is, and if the idea has been rejected, there is detailed information on the reasons why it was rejected. This data collection prevents the employees to give the same idea that is already given and analyzed. The target is also to share information that is behind improvement decisions to all company employees.

4.2. Continuous improvement project PDSA Cycle

After the continuous improvement idea has been approved in the PEP-team, the new project will be created to ETS-Lindgren's ERP system. Company uses

SyteLine ERP (Enterprise resource planning) system for customer projects and for manufacturing planning purposes. Complex customer projects are opened using naming system PRxxx and component orders are named ORxxx where "xxx" is a consecutive number. For new continuous improvement projects, the company starts to use naming system CIxxx. Creating a CI project to ERP system helps to allocate CI project's costs and tracking. In Finland, it's possible to get funding for investments (TEKES, Finnvera) and one requirement for that is accurate cost tracking. Collecting all project costs from SyteLine helps ETS-Lindgren to create cost reports from CI projects and to give needed reports to management and investment financiers.

ETS-Lindgren uses PDCA-cycle based method for CI project's implementation. This is widely used in the industry, especially for process and product improvements. The PDCA methodology is a continuous loop of planning, doing, checking and acting. This makes this model optimal for continuous improvement's purposes.

4.2.1. CI Project Initial phase and Kick off meeting

For every CI project, the PM will be selected from ETS-Lindgren's project management team. The same PMs work with the customer projects and project process flow has similarities with CI process flow. That helps the project team and stakeholders to start working using a new project model for CI projects.

After creating project folders and opening the project to ERP system, the PM sets-up a KO (Kickoff) meeting for the new CI project. The PM invites employees to the KO meeting from different departments that are working with the improved process/product. During the meeting, the project team sets up project goals and defines how success of the projects can be measured. As mentioned in earlier chapters, ETS-Lindgren's end products are used in electromagnetic shielding and in many cases, the CI project also needs to be verified from other points of view than only productivity and cost reduction. In theory, every improvement project that affects to parts that are used for shielding purposes needs to be tested carefully against shielding specification of particular products. This is an important thing to point out during the KO meeting. Testing costs and resources have to be added to the project plan when there is need to RF-test. ETS-Lindgren has facility in Finland where it is possible to perform attenuation or mechanical tests needed but measurement equipment is often on project sites. That's the reason, why it's important to schedule measurements at the beginning of the project. KO meeting minutes' template is the same that is used for customer projects. This is shown in appendix 3.

4.2.2. CI project planning and problem identifying

During PDCA model's planning phase, the goal is to identify the problem that is described in the idea form. The PM also creates a project WBP and defines used resources for projects. During the planning phase, the PM defines the budget for the project and creates ETC (estimate to completion) template for future cost tracking.

The employee who gives the improvement idea also attaches preliminary cost calculations or other data that can help analyzing the problem in more detail. After the KO meeting, the project manager starts to work on analysis for given improvement idea. In many cases, the PM has to check history cost data from ETS-Lindgren's ERP system to get quantitative data about the problem. To get a clear picture about manufacturing relating problems, the PM interviews employees on the shop floor and the manufacturing foreman. Approaching the problem from different angles gives deeper understanding of root causes of the problem. Illustrative tool for RCA (Root Cause Analysis) is fishbone diagram. It is easy to show causes for specific event using fishbone diagram. The PM is responsible for involving every needed stakeholder to work with this analysis to ensure full coverage RCA. In Figure 11 is the developed template for ETS-Lindgren's RCA. This RCA will be filled together with the selected team that is working on deeper analysis.

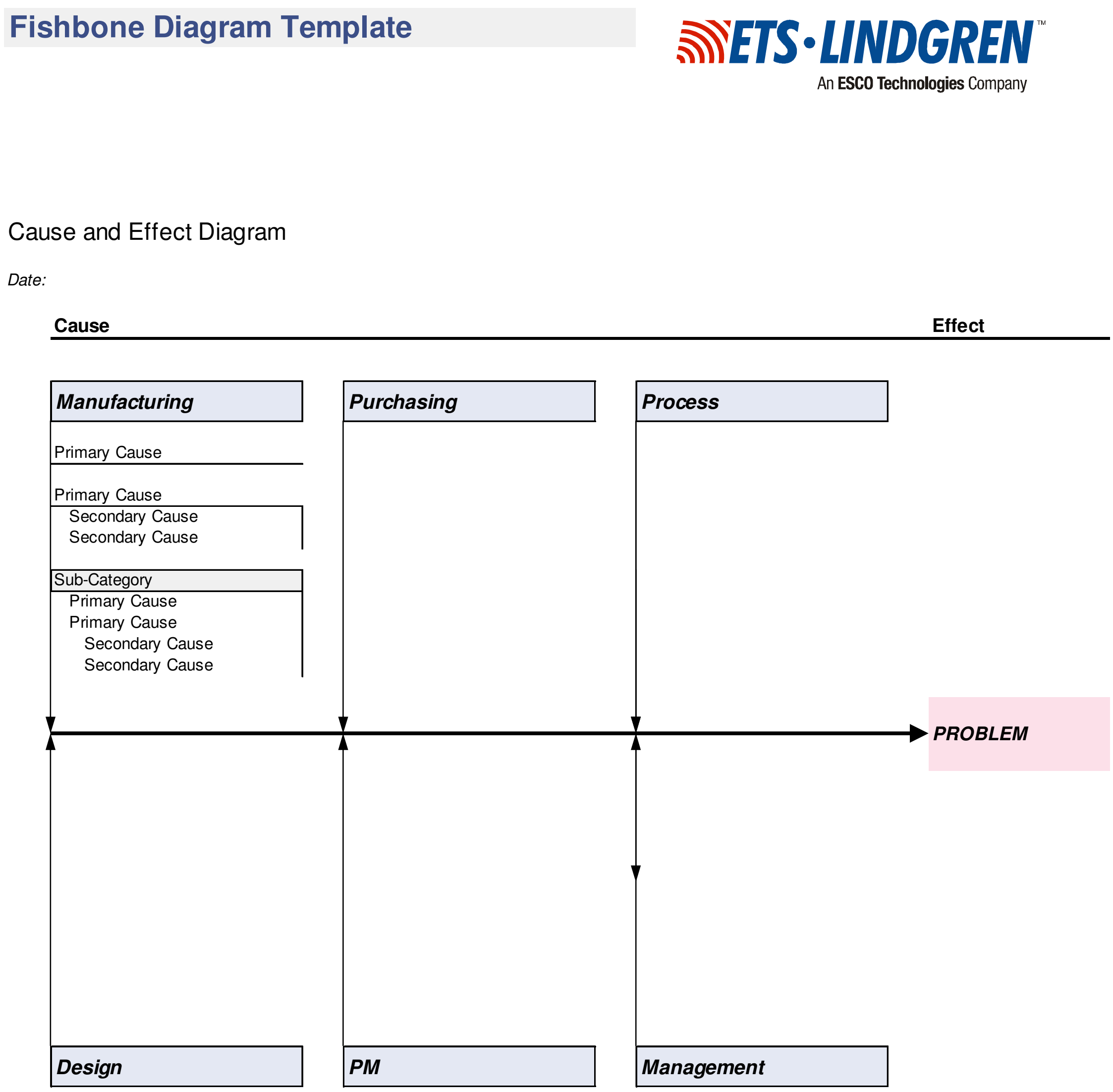

Figure 11: ETS-Lindgren RCA template.

The PM can modify the main categories of the template and add or delete branches. Conclusion will be made after all possibilities are added to the fishbone diagram. After that, the PM can concentrate on working more focused on founded solutions. At this phase of the project, it´s possible that significant findings are made during the root cause analysis which makes the CI project's profitability questionable. In that case, the PM reports these findings to the PEP team and the project's situation will be re-evaluated. If new foundlings chance the project ROI or other key figures, the project may be cancelled or put on hold to wait for exact calculations.

4.2.3. Project work breakdown structure

After problem root cause analysis has been completed, PM creates the project WBS. ETS-Lindgren uses Microsoft Project software for project task breakdown and resources allocation. Gantt chart is a visual form to show different tasks' dependency on each other and also to define project bottle necks. By creating WBS, the project manager defines needed resources for particular tasks. This phase is critical for project's success. Every task must have a named, committed resource to make a successful project possible. In real world, this is often challenging because most of the ETS-Lindgren's resources are also working with customer projects and these projects have the highest priority. Often the CI project needs resources from different departments and in some cases even from different countries and this makes resource management challenging. The PM´s responsibility is to keep the CI project's WBS and schedule up-to-date and inform stakeholders if needed.

ETS-Lindgren's example of CI project's WBS is described in figure 12. This can be used for CI project's WBS template. Tasks are divided at this particular project into four different main categories based on company departments. Project management covers the analysis phase of the project and is responsible for the project's approval process. Also post mortem and informing the stakeholders is included in the project management's tasks.

Often ETS-Lindgren's CI projects' goals are cost and material savings, and purchasing plays an important role in this. In the example project in figure 12, the goal is to standardize door parts and this will increase purchasing or manufacturing batch size. In the end, this will lead to lower manufacturing cost. Make vs buy decision is also evaluated during analysis phase. The project's WBS file is located at the project's intranet page and this makes it very easy for every project team member to check project schedule and every individual responsibility at the current project. This also helps real time project schedule review because the latest version is always available.

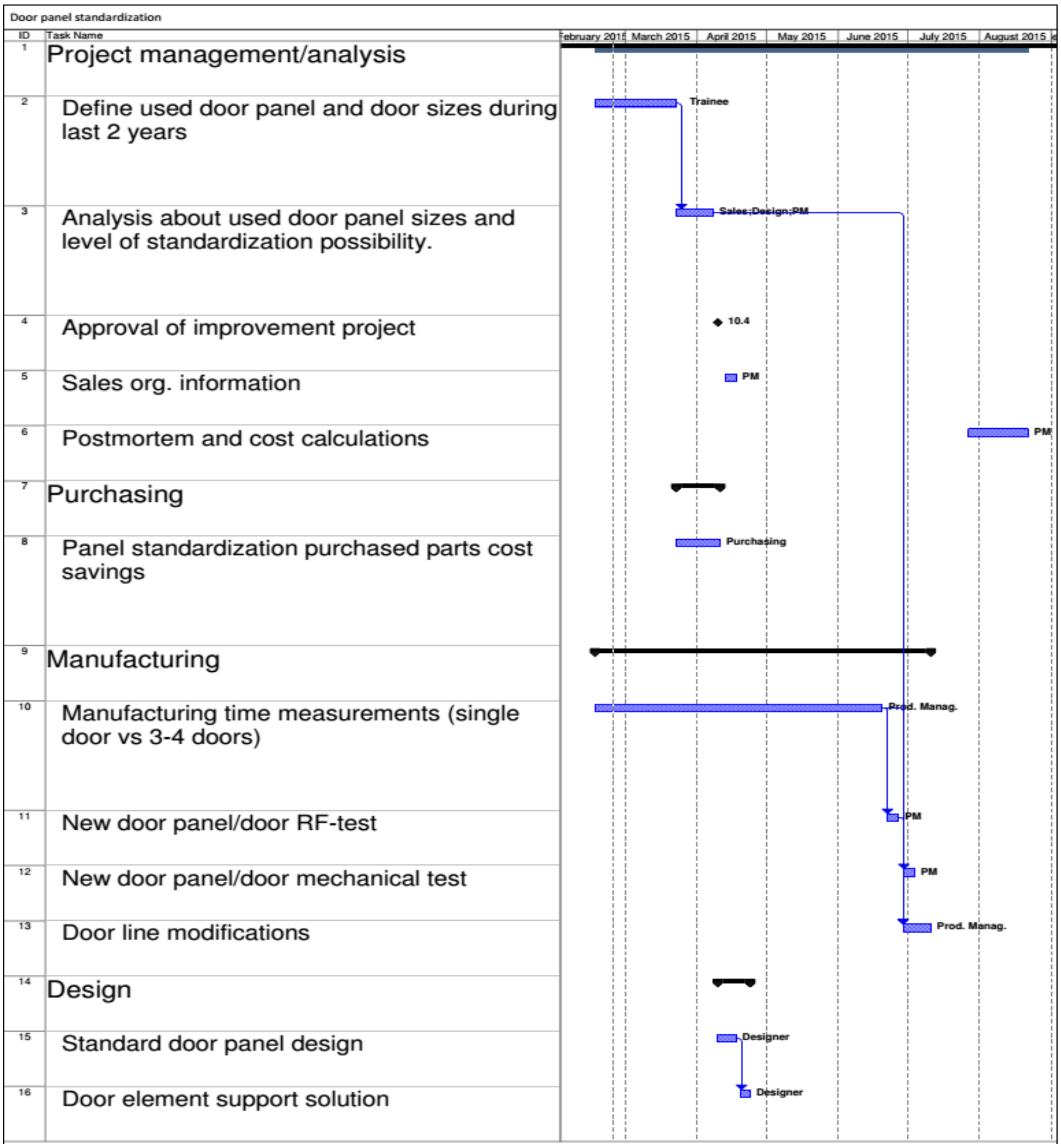

Figure 12: ETS-Lindgren sample CI project WBS.

Manufacturing organization's responsibility is the production tests for updated parts or sub-assembly. In this sample project, manufacturing department measures set-up time and individual door's labor cost to get data about the improved manufacturing method. Manufacturing also performs the sample door's assembly with modified production line and installs the door to demo chamber. This is a common stage in CI projects because many improvements affect manufactured parts.

Design department is responsible for redesigning door structure to support standard size and serial manufacturing. New raw material usage and new part structure need prototyping and iteration until the best solution is found.

4.2.4. CI project cost collection

CI project's material costs are allocated directly for project's job tasks. Production's labor costs are also allocated directly to CI project and the PM can export cost report from SyteLine. The PM updates the ETC (estimated to complete) -file to analyze present situation of the project budget and how project payback time has changed. In figure 13 an excel template is shown which the PM uses for project's payback time analysis and report template for company's management team.

Return on Investment (ROI) Template Package

Year	Costs	Cumulative Costs	Benefits	Cumulative Benefits
0	24 600,00 €	24 600,00 €	8 500,00 €	8 500,00 €
1	11 800,00 €	36 400,00 €	18 900,00 €	27 400,00 €
2	7 600,00 €	44 000,00 €	18 500,00 €	45 900,00 €
3	6 900,00 €	50 900,00 €	16 100,00 €	62 000,00 €
4	5 100,00 €	56 000,00 €	9 000,00 €	71 000,00 €
	56 000,00 €		71 000,00 €	
	ROI:	21,1%		

Interest rate 4 %

Net Present Value (NPV) Template Package

	Year 0	Year 1	Year 2	Year 3	Year 4	Total
Benefits	8 500,00 €	18 900,00 €	18 500,00 €	16 100,00 €	9 000,00 €	
Factor	1	0,961538462	0,92455621	0,888996359	0,8548042	
PV of Benefits	8 500,00 €	18 173,08 €	17 104,29 €	14 312,84 €	7 693,24 €	65 783,45 €
Costs	24 600,00 €	11 800,00 €	7 600,00 €	6 900,00 €	5 100,00 €	
Factor	1	0,961538462	0,92455621	0,888996359	0,8548042	
PV of Costs	24 600,00 €	11 346,15 €	7 026,63 €	6 134,07 €	4 359,50 €	53 466,36 €
Net Present Value:		12 317,09 €				

Figure 13: CI project ROI and NPV calculation templates.

The PM updates ROI (Return on Investment) and NPV (Net Present Value) calculations regularly and if cost forecast or actuals change significantly, this might be a reason to put project for re-evaluation with the PEP-team. It´s obvious that benefit calculations also impact the project's ROI and the PM updates benefit calculations regularly with sales or with manufacturing (depends on the CI project's type).

4.3. CI project's execution phase

During the CI project's execution phase, the new solution will be developed and prototypes are manufactured. Different project content obviously creates different output but mainly ETS-Lindgren's CI projects include parts and improvements that are related to the end products and need prototyping before final acceptance. During the CI project's do phase, most of the project documentation are created. All CI project documentation is collected into intranet's folders. This enables easy access to project documentation to all ETS-Lindgren's employees. This also makes it easy to track history data for old CI projects and decision making criteria. In figure 14, is shown ETS-Lindgren continuous improvement intranet page.

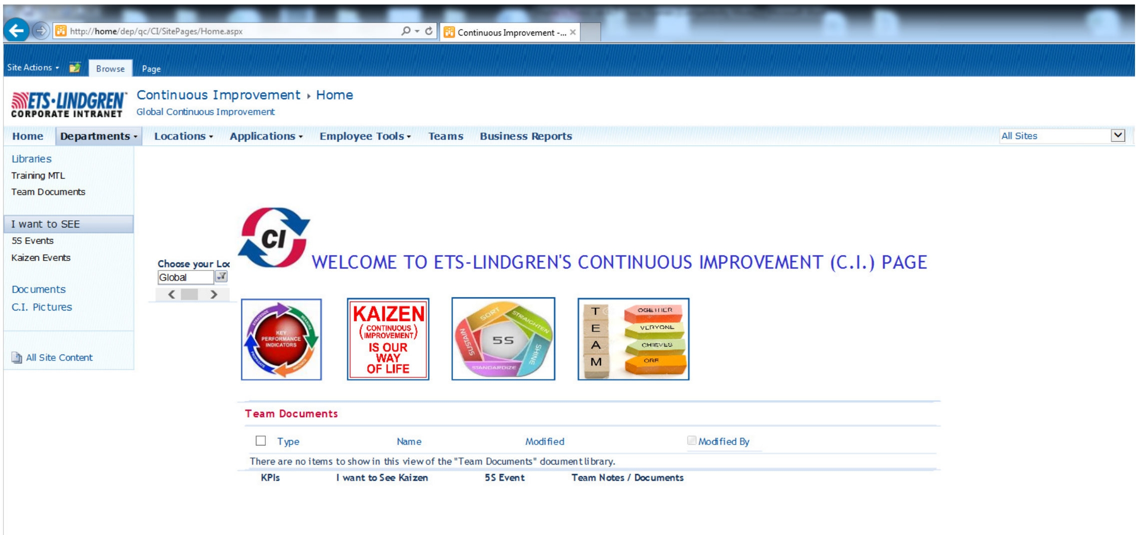

Figure 14: ETS-Lindgren intranet CI page.

Execution phase includes product and part testing and documenting the results. RF-test results are collected into the CI project folder for future use. This is particularly important information about the mechanical solutions' affects to shielding performance. This data is useful for global improvement projects and might save expensive testing time in future. Also, all manufacturing test methods are documented to project folder.

After planned tests are completed, the test data will be put together to solution selection matrix. In many cases, there is no need for solution selection but, for example, a new product ramp up with different production line configuration this is useful tool. Solution selection matrix template is shown in figure 15.

ETS·LINDGREN
An ESCO Technologies Company

Priorization matrix template Values 0 -10

Selection Criteria	Cost	Manufacturing time	Decreased defects	Easy to implement	Capacity planning	Total
Weights	1	1	1	1	1	
Solution 1	6	3	2	4	5	4
Solution 2	8	9	9	9	2	7
Solution 3	8	5	5	3	3	5
Solution 4	7	5	9	10	9	8

Figure 15: Solution selection matrix template.

In the upper row different criteria is mentioned and every solution will be evaluated against these. The PM can change selected criteria based on the CI project's type. The left column shows average value for each solution. It´s also possible to give weight coefficients for every selected criteria to highlight its importance. According to Aartsengel and Kurtogl (2013), it´s important to get employees from different departments involved in solution selection process. This eases "selling" the new, improved solution to employees and speeds up the learning process.

4.4. CI project's post mortem

During CI project's study phase, the PM performs the post mortem and analysis of how the project goals were met. The PM exports final cost data from SyteLine and updates cost estimate files, ROI calculations and makes the conclusion about project's overall costs. An important post mortem target is to learn from the project and collect critical items for future projects.

The PM evaluates measured data from the execution phase and compares this data to the project's goals. If the CI project has included shielded parts and RF test was performed, the PM makes conclusion if the particular part is suitable for the product category it was supposed to fit. This is the most critical evaluation criteria and valuable for learning.

During the post mortem analysis, the project's plan and schedule are evaluated. Under evaluation are the project plan's documentation details and project schedule. Detailed list of post mortem evaluation questions are mentioned in CI project post mortem template. That is shown in appendix 4. This template covers the planning phase's and execution phase's evaluation. There are also questions related to human resources that cover the evaluation of the project's team member's competence.

At the beginning of post mortem analysis, the project team goes through an overview of the project's goals, accomplishments and problem areas. The topics of this part are shown in Figure 16 where the main page of CI project's post mortem template is.

ETS·LINDGREN™
An ESCO Technologies Company

CI PROJECT POST MORTEM

Project number: ____________________ **Date:** ____________________

Project Overview:

- What were CI project goals?
- How did the project finalize?

Key Accomplishments:

- What worked well?
- Project main achievements?

Key Problem Areas:

- What project processes didn't work well?
- What specific processes caused problems?
- Technical challenges?

Post Project Tasks/Future Considerations

- Ongoing development and maintenance considerations.
- What actions have yet to be completed and who is responsible for them?

Figure 16: CI project post mortem form main topics.

This part's goal is to collect qualitative data about the CI project and open discussion with the project team. The post mortem meeting is supposed to be an interactive meeting with discussion that is also one important learning aspect.

4.5. CI project's closure

The CI project's closure is the main part of PDSA cycle's act phase. During this phase, the PM collects final documents to ETS-Lindgren's intranet project folder. Documentation includes 2D/3D drawings, BOM (Bill of Materials), measurement reports, finalized project cost data and project schedule. This is important data for future usage. Other PMs can use old project WBSs as a template for new CI projects or for new employees' training purposes.

During this phase new standard policies and practices must be established to ETS-Lindgren's organization. The PM organizes, together with department managers, training and informs all needed organizations about the improved product or process.

5. DISCUSSION AND CONCLUSIONS

This Master's Thesis was about developing CI implementation and idea collecting process in case of ETS-Lindgren. ETS-Lindgren hasn´t had a clear CI implementation process in the Finnish office. The type of this study was a case study and mainly qualitative research methods were used. Materials for this study were collected through interviewing key personnel from different company locations and departments. Literature review contained a wide range of literature about CI improvement. The developed CI implementation process was created by using models described in literature and the company's present customer project process flow. During this thesis, CI implementation process and CI idea collection method were created. This study succeeds in creating a description for CI implementation process and also a wide range of templates for company's CI projects' use.

5.1. Research Results

During this thesis a complete process description for the CI implementation process was developed. The process description includes responsibility areas for every process step and sub entities. The process description includes file templates for CI improvement projects' use. This creates a systematic and identical documentation process for every CI project which makes project reporting and monitoring formalized for ETS-Lindgren's management. The company also starts to use a new project category in ERP system. This created project category is used for CI projects and through using different naming system, it´s separated from the customer projects. This new project category helps the company to collect CI project related material and labor costs and this information can be used for internal and external purposes.

This Master's Thesis' outcome fully supports ETS-Lindgren's global strategy and the developed process underlines that everyone has an opportunity to give improvement ideas and those are processed systematically. Following is direct quotation from ETS-Lindgren's Strategic plan. "We are a learning organization committed to Continuous Improvement (CI) through the implementation of best practices regardless of the source of the idea." (ETS-Lindgren Strategic Plan, 2015.) To emphasize CI's importance for the company, ETS-Lindgren's Finnish office has added CI project quantity to company's KPI (Key Performance Indicator). KPI defines the quantity of completed CI projects during the monitoring period. This KPI indicates CI's overall activity during the monitoring period. Adding CI related KPI helps the company to highlight CI's importance to the company's employees. ETS-Lindgren informs company employees about KPI's and these trend regularly during "factory meeting" that is organized every month.

The main tool that was created for ETS-Lindgren's CI's purpose is the intranet site that collects all CI projects' documentation to the same location. This allows every ETS-Lindgren's employee to check CI project's status, documentation and also review projects history data. CI intranet site contains the new CI idea form and a solution to submit form for processing. Using company's intranet site for CI projects allows also employees from different countries to review CI projects' data and contents. Collecting all CI projects' data to the same easily accessible location for all company employees globally enhances ETS-Lindgren's CI related productivity in long term.

This created CI implementation process flow has activated the company's employees to give improvement ideas more often than before. The reason for this behavior change is that CI ideas' processing has been clarified and CI idea's status tracking has been improved. The shop floor CI teams have also lowered the threshold for individual employee to give ideas and also team work has created brainstorming-like effect. The company employees feel confident that every improvement idea will be processed and they get feedback of the reasons behind rejection or approval of every idea. In future, this created process will increase the company's productivity and help company to cut costs and delivery time on the shop floor.

5.2. Suggestions for Future Research

Results (of the study?) were mainly similar as in scientific literature. The biggest deviation was that in literature, the process model is described in detail, and on theoretical level all possible scenarios and variables have been taken into account. To complete a CI implementation process that is described in literature a dedicated CI personnel is required and in many cases this is possible for only large companies. ETS-Lindgren uses for CI activities personnel that mainly works part time with CI process. This created limitations for process steps and process coverage.

In practice, it´s almost impossible to create a process that covers every detail and all steps of the CI project. That wouldn't be a productive way to work and companies' don´t have the resources to cover too laborious processes. The selected process model was an applied model based on PDCA process model. The selected PDCA areas and process steps were selected using information from old CI projects and suitability for ETS-Lindgren's business area. The process flow and ERP related details tried to follow the same guidance as in customer projects. This eased the training process of the company's staff and sped-up the new process' introduction.

Considering future research possibilities, one interesting question is, would it be possible to integrate CI process to cover all company locations all over the world. This case study concentrated mainly on ETS-Lindgren's Finland office's needs but to utilize global organization knowledge, CI process and database need to be global. After created process ramp-up period, it would be useful to investigate pros and cons to expand the developed CI process to other offices. On general level, importing this process should be quite straightforward, because ETS-Lindgren uses the same ERP-system in all different locations. Also software and tools are mainly compatible between different offices.

It would be useful for every SMEs (Small and medium-sized enterprises) that are operating in industry and are planning to create CI implementation process to familiarize in this case study. The case study handles international organization challenges for the CI process and also introduces achievable process' advantages. This case study can be also used for a reference by companies that work in domestic markets only. In that case, the process is simpler and tools' capability problems are minor.

REFERENCES

Van Aartsengel Aristide, Kurtoglu Selehattin (2013). *Handbook on Continuous Improvement Transformation: The Lean Six Sigma Framework and Systematic Methodology for Implementation.* Springer Heidelberg New York Dordrecht London. 643 p. ISBN 978-3-642-35900-2.

Bhuiyan Nadia, Baghel Amit (2005), *An overview of continuous Improvement: from the past to the present.* Vol. 43 No. 5. Emerald Group Publishing Limited

Yanjiang Cheng, Yiqin Wang, Lang Xie (2006). *Empirical Study of Elements and Interrelation about the Current Situation of Continuous Improvement* School of Management, Harbin Institute of Technology, Harbin 150001, P.R.China

P. Punnakitikashem, N. Somsuk, M.W. McLean. T. Laosirihongthong. *Linkage between Continual Improvement and Knowledge-Based View Theory.* Industrial Engineering and Engineering Management (IE&EM), 2010 IEEE 17th International Conference. ISBN 978-1-4244-6483-8

V. Cruz Machado, José Tavares. *Modeling Organizations Based on Value Streams.* Industrial Engineering and Engineering Management, 2007 IEEE International Conference on. ISBN 978-1-4244-1529-8

Aristide van Aartsengel, Selahattin Kurtogl. *Handbook on Continuous Improvement Transformation.* Springer-Verlag Berlin Heidelberg 2013. ISBN 978-3-642-35900-2

Wang Jia, Ge Jiaoju, Lu Qiang (2012). *A review of stakeholder analysis.* System Science. System Science, Engineering Design and Manufacturing Informatization (ICSEM), 2012 3rd International Conference. ISBN 978-1-4673-0914-1

Rao, Radnakrishna C. (1973). *Linear Statistical Inference and its Applications*. 2. painos. New York: Wiley.

Brealey, Richard A., Stewart C. Myers & Franklin Allen (2008). *Principles of Corporate Finance*. 9. ed. New York: McGraw-Hill. 976 p. ISBN 978-007-126675-8.

Department of Mechanical and Industrial Engineering, UNIDEMI, FCT
University Nova of Lisboa, PORTUGAL

Di Zhang, Xiuquan Deng, Rongjun Zou.(2009) *Study on the Organization and Work Breakdown Structure of the International Academic Conference Event Management*. Industrial Engineering and Engineering Management, 2009. IE&EM '09. 16th International Conference on IEEE. ISBN 978-1-4244-3671-2.

Tim Kotnour (2000). *Organizational learning practices in the project management environment.* Emerald Group Publishing. 393-406 p. ISSN 0265671X

Cynthia Snyder (2013). *Project Manager's Book of Forms : A Companion to the PMBOK Guide.2nd edition.* John Wiley & Sons 235 p. ISBN 9781118537404

Van Aartsengel Aristide, Kurtoglu Selehattin (2013). *Handbook on Continuous Improvement Transformation: The Lean Six Sigma Framework and Systematic Methodology for Implementation.* Springer Heidelberg New York Dordrecht London. 643 p. ISBN 978-3-642-35900-2.

ETS-Lindgren 2015. Official website. Referred (17.2.2015). Available at <www.ets-lindgren.com>

JingFeng NingI, Zhiyu ChenI, Gan Liu (2010). *PDCA Process Application in the Continuous Improvement of Software Quality.* International Conference on Computer, Mechatronics, Control and Electronic Engineering (CMCE). ISBN 978-1-4244-7957-3

Liu Jian-Bing, Xie Ji-Hai, Ren Hong (2008). *Critical Chain Project Management Based Heuristic Algorithm for Multiple Resources-Constrained Project.* Business and Information Management, 2008. ISBIM '08. International Seminar on (Volume:1). ISBN 978-0-7695-3560-9

Iltuzer, Tas & Gozlu (2007). *Implementation of Activity-Based Costing in e-Businesses*. Istanbul Technical University, Faculty of Management, 5.8.2007. ISBN 978-1-8908-4315-1

Jing Feng Ning, Zhiyu Chen & Gan Liu (2010). *PDCA Process Application in the Continuous Improvement of Software Quality*. Mechatronics, Control and Electronic Engineering (CMCE), 2010 International Conference on, Issue Date: 24-26 Aug. 2010. ISBN 978-1-4244-7957-3

Helen Wagner, Sue Morton & Chris Backhouse (2010). Only room for an Ideas Man – or is there more to CI for the less creative? Industrial Engineering and Engineering Management (IEEM), 2010 IEEE International Conference, ISBN 978-1-4244-8501-7

APPENDICES

APPENDIX 1

ETS·LINDGREN
An ESCO Technologies Company

CONTINUOUS IMPROVEMENT IDEA

Date: ____________________

Employee Name: ____________________

Idea Details

Complete de form below

NOTE – If applicable – Attach all supporting documentation

For PEP Team Use Only

Date Replied: ____________________

Comments: ____________________

APPENDIX 2

CI IDEA DATABASE

ETS·LINDGREN
An ESCO Technologies Company

Idea description	Status	Idea proposed by:	Data:
Door panel standardization	Under investigation	JuVi	15.1.2015

APPENDIX 3

ETS·LINDGREN An ESCO Technologies Company	EMEA K.O.M. Form : 4.4.50		
	Last revision date:	Revision	Owner:
	19th Dec. 2014	11	Manager of PM

Original Project Number:

Meeting Participants:

Sales: Projects: Test Solution:

Design: Production:

Purchasing: Other:

1- **PROJECT SCHEDULE** (add if necessary) – or copy and paste Gantt chart

PO:
Submittal dwg:
Customer approval:
Production dwg:
Production start:
Delivery ExW:
Installation start:
Installation finish:
Independent testing:
Magnet delivery:

2- **AGREED ACTIONS:**

Item No.	Action	Who	When
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			

3- **LIST OF CRITICAL ITEMS:** (tight delivery date, non-standard items, special contract terms, performance issue …)

Item No.	Explain risk	Method to mitigate the risk:
1.	Export licence required	
2.		
3.		
4.		
5.		

APPENDIX 4

ETS·LINDGREN
An ESCO Technologies Company

CI PROJECT POST MORTEM

Lessons Learned:

Category	Lesson Learned	Achieved?	Comments
Project Planning	Product concept was appropriate to Business Objectives		
	Project Plan and Schedule were well-documented, with appropriate structure and detail		
	Project Schedule encompassed all aspects of the project		
	Tasks were defined adequately		
	Stakeholders (e.g., Sponsor, Customer) had appropriate input into the project planning process		
	Requirements were gathered to sufficient detail		
	Requirements were documented clearly		
	Specifications were clear and well-documented		
	Test Plan was adequate, understandable, and well-documented		
	Project budget was well defined		
	End of Phase Criteria were clear for all project phases		
	Stakeholders had easy access to Project Plan and Schedule		
Project Execution	Project stuck to its original goals		
	Changes in direction that did occur were of manageable frequency and magnitude		
	Project baselines (Scope, Time, Cost, Quality) were well-managed (e.g., changed through a formal Change Control Process)		
	Design changes were well-controlled		
	Basic project management processes (e.g., Risk Management, Issue Management) were adequate		
	Requirements – specifications – Test Plan were well-managed (e.g., Requirements Management System was used)		
Human Factors	Project Manager reported to the appropriate part of the organization		
	Project Manager was effective		
	Project Team was properly organized and staffed		
	Project Manager and staff received adequate training		