Toward a Web-based Application to Resolve Physical Pulse Board Issues

Navid Torabi and Mahdi Dinparvar
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Contact Information:
Author:
Mahdi Dinparvar
E-mail: madk10@student.bth.se

Author:
Navid Torabi
E-mail: nato10@student.bth.se

External advisor:
Staffan Olsson
Repos AB
Address: Repos Mjukvara AB, Södra Strömgatan 9, 44143 Alingsås
Phone: +46(0)70-2234676

University advisor:
Jürgen Börstler
Software Engineering Research Lab

School of Computing
Blekinge Institute of Technology
SE-371 79 Karlskrona
Sweden

Internet : www.bth.se/com
Phone : +46 455 38 50 00
Fax : +46 455 38 50 57
ABSTRACT

A decade ago, Toyota, an automobile manufacturer from Japan, came up with a new production system which started the automobile industry called “Lean manufacturing” [1]. Over time, the popularity of the system became apparent and it became the Toyota Production System (TPS). Following this technological development, “Len enterprise” a new concept was produced with the sole purpose of eliminating wastes in every function of the entire organization. As of present, as far as product developing companies are concerned, the development process has become more complex. For instance, in Scrum software development as well as in Lean product development, tools for planning a project using walls and boards have been developed. These methods have so far proved to be very efficient, in so far as the visualization of the work performed, as well as the prioritization of new tasks is concerned. However, there are notable challenges in synchronization, version control and traceability among a company’s different projects. This thesis, investigates how Physical Pulse Board is used and how it can be improved through the introduction of a web-based application for eliminating of difficulties of using Pulse board especially in global environment where different people from various locations might need to join the meeting.

The paper consists of three parts. In the first part one set of interviews were conducted along with an observation to figure out related difficulties with the use of Physical Pulse Board especially in global environment. Following this, another set of interviews were conducted to help find out how these issues can be eliminated or resolved.
Considering that good principles can never be useful, unless they are applied and used in reality, in the second part of this report, a web-based application was developed to help bring improvements using Pulse Board in global environment based on the finding from the first part. It was then that evaluation of implemented software was done through a workshop with Hellström, and Dr. Amer Ćatić. It is worth noting that the two persons are the Lean Product Development Specialist chosen for market analysis given that the two had implemented the Physical Pulse Board in their organization.

**KEYWORDS:** Lean, Product development, Lean Product Development System, Visual Planning, Pulse board
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Chapter 1

1.1 Introduction

Two major factors which increase complexity inside companies are the number of different products that are produced by these companies, as well as physical location of their teams. These complexities impose extra waste in different areas like inventory, processes, maintenance, quality, suppliers, production control and scheduling in the companies [2]. The term visual planning originates from the lean concept that developed by the Toyota Company in coordination with the Japan Management Association Consultants (JMAC). “Lean means manufacturing without waste” [3]. This concept emerged for the first time at Toyota with the name of “Toyota production system” [3]. Waste in product developing companies consists of eight categories i.e. overproduction, inventory waste, defective product, over processing, waiting, people, motion and transportation [4]. Waste of resources have a negative influence on quality, delivery time and cost; therefore, eliminating them contributes to higher customer satisfaction, profitability and efficiency [4][5]. The term lean was developed solely to help shorten the Toyota’s lead time for purposes of developing new car models alongside increasing the workers’ productivity. According to Womack and Jones, lean is a way of thinking not just a technique [6].

Visual planning often consists of a matrix structured boards upon which deliverables, problems, activities and events are presented [1]. Pulse board serves as the example of visual planning. It is a method that is often used to improve the efficiency of communication within a team. It helps in creating a common overall picture through making the team’s obligations and commitment. Creating pulse in the product development through lean thinking explains the theories and
concepts behind pulse method, pulse boards and pulse meetings. Pulse meetings are those decision meetings in which the participants work while standing beside the visual planning boards [7]. These meetings encompass visualizing information, increasing communication and accelerating the process of decision making. The pulse boards, on the other hand, are the white boards that consists a ray of items [8]. Important deviations are visualized in pulse board. Each deviation is examined and explained during the meeting; therefore, if possible appropriate actions will be made accordingly. If it cannot be solves with that level e.g. project level, it is moved down or up to the next level, producing a flow in the organization. A Pulse panel is a panel, which joins all tasks with each line organization. On one axis all tasks are imagined and on the other axis line categories are presented, and together this creates a matrix. In each square that joins a venture and a range a shade marking is placed, this marker could e.g. have along with natural, red, yellow-colored and white-colored. This marker communicates if everything is ok in the venture (green), if there is a problem (red), if it could become an issue (yellow) or if the venture and the range do not have any connection, white-colored [8]. Only red and yellow-colored indicators are discussed during the short meeting. The meetings, as well as the visual planning boards serve as means of facilitating communication. Through the abstract information, the communication becomes concrete. This is because through this, team members get access to one specific picture and through it they get to see what is communicated. Pulse helps individual knowledge to be shared accordingly. Additionally, pulse provides an allowance for people to contribute ideas since it allows them access to information and makes decision making easier. By and large it allows individuals to participate in the planning thus creating the understanding of the means of reaching the set of objectives for easy attainment. Pulse board makes possible that team members constantly get feedbacks. It also enables them to participate in the planning so
that they are able to gauge the progress of the company on a weekly basis [8]. Figure 1 shows a sample of Pulse board which has been created after observing the company.

![Image of Pulse board]

Figure 1: A sample of Pulse board

To resolve insufficiency, lean practitioners in some companies use physical boards and walls to figure out and manage processes and progresses of different projects. In this regard, weekly meetings are held in front of physical boards to enhance communication, share of knowledge and understanding of the companies’ processes. As a result, this visualization contributes to transparency enhancement on projects progresses, processes, priorities and resources supplying [1]. Although applying Pulse boards enhances transparency of companies’ processes, priorities and resources supplying, there are problems with synchronization, version control and traceability among product development teams of multi-project companies. This is because, in most of cases, product development teams of multi-project companies are physically separated
from each other. Hence, the status of Pulse boards cannot be changed between meetings due to lack of synchronization among boards and other tools such as Excel files which are used by remote teams. Another shortcoming of applying Pulse boards is that no information is kept about the previous status of the board even when all teams are at the same location. These problems are of paramount importance because they cause waste and waste prolongs delivery time, increases cost and unnecessary added activities to companies [4]. Therefore, the aim of this study is to gather data, general issues, challenges and solutions related to the Physical Pulse Boards, and then introduce an approach to omit or reduce the detected drawbacks of applying Physical Pulse Boards.

1.2 Aims and Objectives

This will be a research that will set out to among other things achieve a number of objectives. First, the researchers seek to use this medium as an avenue to explore issues that deal with applying Physical Pulse boards in multi-project companies with physically separated and/or cross-functional teams. Secondly, the research shall set out to gather data, general issues, challenges and solutions related to the Physical Pulse boards, and then introduce an approach to omit or reduce the detected drawbacks of applying Pulse boards. It is also of prime importance for this research to investigate difficulties on applying Physical Pulse boards in global environment, and suggest some solutions to tackle them. As the software can be used to decrease restrictions of conventional systems and helps having better and faster communication, coordination and collaboration; therefore, implementing a software supported approach that can be used instead of Physical Pulse boards to synchronize the work of physically separated and/or cross-functional teams is considered as our solution. Therefore, closely related to the issues of Physical Pulse Board and web-application, this research shall further seek to develop a software application that can help resolve the detected shortcomings of applying physical Pulse boards in
distributed product development teams. Furthermore, the research is going to be used as an avenue for conducting a comparative analysis on how to evaluate Physical Pulse Boards issues using web application and for it to realize this, the research will set out to elicit experts’ viewpoints to figure out their suggestions on how to tackle current issues of applying Pulse Boards.

The objectives outlined above are going to be the basis of this research work in several ways. For instance the purposes to be achieved will determine the general realization of the completion of the research work because the objectives need to be achieved before the research can be said to have been brought to a successful end. Again, it is going to determine the research questions with which the researchers will have to work with. Finally, the aims and objectives outlined are going to determine the type of data to be collected at the data collection stage of the research work.

1.3 Research questions

The researchers have set out research questions in an attempt to identifying specific considerations to make in order to achieve the purposes outlined above. The research questions are said to have very close relation with the aims and the objectives of the study in the sense that the research questions are going to be tackled at discussion level. To this end, the following research questions shall be considered:

- What are the key issues of applying physical Pulse boards in multi-project companies with physically separated development and/or cross-functional teams?
- How can the detected issues be resolved with the help of the web-based application?
After finding the issues of applying physical Pulse boards in the mentioned contexts with answering the first research question, we hold interviews with expert users to ask their suggestions to answer the second research question.
Chapter 2

2.1 Related Work

Literature was reviewed to gain an initial understanding of visual planning. In this regard, communication found to be one of the upmost important factors in every project and stated to be a major problem failure cause [9]. It is rather hard to define communication term exactly; however, it may be seen as the basic social activity which information is transferred from one person to another [9]. The communication is a two-way process so that the transmitter should make sure that the message has been received and understood correctly [9].

Studies including Josephon & Saukkorii; Winch; Tonnquist; Meyer, & Allen, indicate that efficient communication is the benefit of visual planning [10, 11, 12, 13]. These findings are in tandem with the findings of Lindlöf and Söderberg [7]. Other studies also indicate that engineers are deeply involved in decision making especially while using the visual methods and that the method functions well as gathering point for engineers for the discussion concerning issues and where they need to agree on the given next move to be made in order to move forward [10, 11, 12, 13].

Visual planning method helps to make communication more effective within a team. Its goal is to create a common overall picture for all team members [14]. As the two words Planning and Visual point out, this method indicates how to visualize planning. The term Visible Planning is occasionally also used instead of visual planning. It is also referred to as VP (Visual Planning). It was first developed by Toyota and Japan Management Association Consultants (JMAC) in order to decrease Toyota’s lead-time and increase productivity of clerical workers [15]. They made one of the important innovation related to visual control [16]. Obeya (big room) was introduced in
2000 by Toyota. Managers and engineers related to a project are gathered in a big room [16]. Several visual tools exist in this room which make possible to indicate status of the project, quality information, blue prints and other measures to see how the project is proceeding. The uses of obeya rooms reveal several benefits including faster decision making, data collection and communication. Team spirit was also considered as other benefits of using obeya [16].

Lindlöf and Söderberg [7] studied the use of visual planning at five product development companies and found two merits; coordination and communication. [7]. These studies indicate that the visual planning does facilitate communication through face to face communication that is created through the visual planning meetings and the overview of the work in the team provided by visualization upon the boards relative to the information overload due to the software based systems. The researchers further noted that the ability to coordinate the efficiency of the task is provided by both the high frequency meetings, and the overview due to the board. Lindlöf and Söderberg, as well found out that since team members often update the members, as well as the status of the project, there is often provision of the work load [7]. It was also mentioned that possible and real problems of the project can be dealt with at an earlier time as the result of updating current status of the project, member’s workload and member’s current activities.

Members are expected to always specify the activities in progress in a frequent basis following a high frequency of meetings. After doing a research on visual planning, Söderberg and Alfedsson, noted that visual planning is quite useful for the teams that entail product development to handle complexities of coordinating their tasks [17]. They, however, noted that visual planning for those teams lacking a clear need to coordinate the activities of members alongside the deliverables on the regular basis, were less effective [17]. They also noted that team size was also a key factor, in
which case where the team was small, a structured communication is not needed [17]. In this study, they found out that a team composed of 6 to 12 members was appropriate whenever using the Visual Planning [17]. It was claimed that the ability to equalizing the workload is restricted if the competences differ a lot in a team. Project members may see this function as a control system; as a consequence, they may be reluctant to state planned finish dates and other necessary information needed in this method [17].

The simplicity and clarification that comes with VP cause it to act as rumor killer. Communication and decisions are strengthened in VP in contrast to the usually static status of software-based plans, by the availability of real time information. The swift pace is an important factor which causes people to talk and listen in a more active way to each other [7]. To avoid long discussion an hourglass is used in some companies so that if detailed discussion is necessary it takes place after the meeting just with the members it concerns.

Lindlöf and Söderberg explain VP as a “simple method where activities and deliverables are outlined and illustrated on a physical planning board and discussed at frequent meetings”. They also describe visual planning as a “rather analogous approach to planning the tasks of product development teams” [7]. Lindlöf and Söderberg state that the analogue format is underlying both weaknesses and strength of visual planning method [7]. Söderberg indicates that the analogue nature encounter opposition in some cases due to its simplicity and is recognized unprofessional by some people [18]. Shared understanding, efficient communication, efficient leveling and ability to prioritize tasks were identified by Lindlöf and Söderberg as the benefits of lean visual planning [7]. On the other hand, difficulties to track causal link between activities, difficulties working with distributed teams and difficulties of keeping historical data are the three major difficulties related to visual planning [7, 16, 18].
Short meeting with the focus to find deviation and synchronize the work with the help of Visual Planning and signal systems is a technique which sometimes is called Pulse meeting. The technique has been used successfully by many organizations as a way to differentiate work meetings from status meetings. Participants of the Pulse meeting need to come prepared in order to reduce waste. If a deviation is reported without any solutions, the participants try to find solution suggestion immediately during the pulse meeting or sometimes after the meeting [19]. It was claim that a critical deviation that is found shortly after occurring is not a big source of waste; instead a minor deviation that is not discovered for weeks may cause serious problem and big waste. Thus, the way to decrease the influence of deviations is to find them as soon as possible [20].

In tandem with Lindlöf and Söderberg, Sebestyén express that Pulse meetings are decision making gathering where the participants are standing in front of the visual planning board [16]. Pulse meeting is represented as “a way of working that increases communication, visualizes information, focuses the work process and accelerates decision-making” [16]. The Pulse boards and visual planning boards are white boards consisting of:

- Symbolizing the vision and objective of the project and what it will deliver via an image
- A plan which describes temporary results and delivery points
- Current deviations and issues
- A decision log
- A brief statement of possible risks and action plan
Team member participation is considered crucial in Pulse meetings. Throughout the meetings participants update their related/affected information. Detailed planes and delivery time are created by all members together. Current issues and deviation should be discussed during the meetings. If possible a decision is made right away. If not, a team member is responsible to find necessary information for the next meeting. When a deviation/problem is solved, it should be documented in decision log. The sticky notes should remain until the next meeting if a problem is solved between two pulse meetings. Only one person is responsible for attaching a removing the sticky notes [16].

Pulse meeting need to be short and take place frequently, more desirably several times a week. These meeting intended for decision making but problem solving. The Pulse board is place somewhere, more probably conference room to enable the team member access between the two meetings. The board shall be placed in a way that all people can stand in front of it with the same possibility to see what is happening on it and gradually involved in discussion-making process. Stand up in front of the board makes teamwork easier and helps to prevent participants to get relaxed in chairs like the other meetings [16].

The interaction that Pulse methodology creates between people leads to team work and mutual understanding. It was claimed by Sebestyén that it is not only the meeting that creates the coordination but also the participants [16]. The meeting as well as visual planning boards are means to make communication easier. Summarize information and overall picture simplifies communication between team members.

It is common in manufacturing that problems be hidden which force managers to emergency firefighting (emergent decision) [16]. It is believed at Toyota that people need to know the status
of the project and see if everything is on the plan or problems exist. This is also relevant to conference room where planning meetings are occurring. It is possible to see how the project is going on, whether it is ahead or behind the schedule. Likers claimed the significance of being able to recognize problems just in a quick look to prevent fire emergencies. This problem is solved by visual control; therefore no problems are hidden [16]. There are three important factors that affect the success of implementing the Visual Planning; the role of senior management, team characteristics and team culture [17].

There were other studies explored in this literature that clearly shows the lacking evidence of research done based on this thesis. Derick Bailey, in his study focused on the Kanban Board and pipelines [21]. In this study, the researcher indicated that many teams tend to use the visual control system in outlining various steps that software goes through in course of development. He noted that basing on the surface, there is no clear difference between the Kanban board and the average task board indicating that each of the mentioned boards has columns representing stages a card has to go through before being considered done [21]. According to this study, the Kanban board is a visual indicator, and it is similar to the task board [21]. The differences that he noted in this study were that the real differences entail how the process is approached. As concerns the simple software development Pipeline, Derick Bailey, noted that the software development pipeline operate in a similar way with the grocery store pipeline [21]. In consideration of the columns in the simple pipeline, the study noted that there are three columns for the software development. This includes analysis, testing and development [21]. From the literature, so far explored, it is apparent that these researchers concentrated on other visual processes of the evaluation boards alongside their use and advantages giving planning processes and tools.
In the same vein as Carlsson, Janice and Dag state that a digital version might not be as effective as the analogue one; however, it can be used as a complement to support the weaknesses of the method [23, 24]. The study also claims that digital tools should be used as a complement to eliminate the difficulties of documentation problem [23].

On the other hand, companies like to take advantages of IT tools in their office in order to have paperless office. In general there is no opposition against IT; however, it must be suitable for visual control. Founder of the philosophy stress that as usually only one person is sitting behind the computer may cause isolation from teamwork. This is in accordance as Liker describes it, visual control; but it facilitates the use of our senses like sight, hearing and touch. The best indicators according to Toyota are the ones that make us able to feel, see and hear [22]. In this regard existing agile, Kanban and LPD tools were reviewed to figure out their advantages and disadvantageous.

2.2 Available LPD Tools

This section comprises an organized breakdown of tools mentioned in LPD literature. The tools found in the literature study are mapped into the following classifications:

1) Knowledge sharing tools
2) Customer focused tools
3) Tools for Visual Management
4) Efficiency tools
5) Quality assurance tools
6) Problem solving tools
Several purposes are met with some tools and thus they are placed in multiple categories. The focus of this study is problem solving tools where primary causality is disclosed, investigating to the root cause of every issue. The aim of this method of operation is to escape doing the same thing over and over repeatedly, as a result of that developing waste. Ask why [25, 26, 27, 28], Plan-Do-Check-Act (PDCA) [25, 28, 29, 30], Brainstorming [25, 26] and Value Stream Mapping (VSM) [25, 26, 28, 31, 32] are example of tools in this categories.

Some reasons for these implementation difficulties are easy to find by Looking at the tool review. The tools included in LPD literature are poorly applied between the different tool categories [33]. The big problem that companies face while implementing LPD is that many LPD tools are very obscurely illustrated in the literature [33]. Companies face to these kinds of challenges when starting to implement LPD in their organization, having to find a solution for numerous practical problems by themselves [34]. Despite the fact that it is hard, it might also have good effects as it stimulate companies to find their own customized solution rather than to imitate the concept [34]. This kind of solution needs to be found and developed unhurriedly and with care, one tool at the time [34].

2.3 Available agile planning tools

Software applications are available to assist agile project planning e.g. scrum and Kanban in global environment. Tools that are published online, explained in the literature, introduce by our partner company or mentioned by our interviewees were chosen to be reviewed. Meanwhile existing tools have some differences; they can still be classified by functionalities, design goals and supported platforms. Classifications aid us to distinguish advantages and restriction of available agile planning tools. Agile planning tools are categorized to Wikis, Web Form-Based Application, Card-Based Planning Systems, Digital Tabletop-Based Agile Planning Tool [35].
Some tools concentrate to support actual planning meeting, others focus on documenting the result of planning meeting [35]. Regrettably, the distinctions are not emphasized in the related marketing material and literature [35].

2.3.1 Wikis

Wiki-based tools take advantages of Web technology to manage and publish agile planning information in distributed environment. It provides plain environment and make it easy to control project status, view the progress of team members and update task list. Wikis asynchronous platform make it most useful for progress tracking [35].

2.3.2 Web Form-Based Application

Form-Based Applications were created by taking advantages and limitation of Wiki pages. The structured data stored by such tools supports more flexible performance to manipulate planning information and more complicated work compared to Wikis.

Web form-based systems are usually used to manage and publish agile planning data. Rally, ScrumWorks, VersionOne are examples of commercial products in this group and XPPlanner is an example of open source product. They all use Web forms and set up basic workflow for sharing information.

Web form-based tools support creating, modifying and omitting story cards. In addition, charts are greatly employed in order to visualize the progress. Planning data is set up in iterations, projects, story card and backlog. Web form-based tools generate proper views for different user groups by distinguishing the role of the users like developers or managers [35].

Web form-based applications are widely used in agile planning. However, most of them only support asynchronous usage (such as data sharing, decision making, reporting and daily card
management), the synchronous agile planning, specifically project planning meeting are not supported [35].

2.3.3 Card-Based Planning Systems

These kinds of systems employ visual representations that are similar to index card for describing tasks. They try to imitate physical card based planning. AgilePlanner, CardMeeting and Glue Wiki are categorizing in this group [35]. Other commercial agile planning tools such as Thoughworks Mingle make the advantages of both form-based tools and card-based systems.

The big drawback of Card-based planning systems (like Danube, CardMeeting) is that they do not show who is joining in the planning meeting [35]. They particularly do not display who is interacting with planning tools at the present time [35]. It is crucial to know who is interacting with the tools as it encourages collaboration and communication [35].

2.3.4 Digital Tabletop-Based Agile Planning Tool

New user interaction devices that are employ in planning is called Digital tabletops. Its horizontal display with multi-touch enabled surface provides easy touch-based interaction [35]. Agile Planner for Digital Tabletop (APDT) uses the interactive features of tabletops to improve simplicity and usability during distributed agile planning meeting. APDT also uses handwriting recognition engine to encourage writing on a paper-based story card.

APDT has its own restriction like any other applications that mentioned above. Tabletops are not widely available in industry and they are expensive [35].
Chapter 3

3.1 Methodology

This aspect of the research shall be dedicated to knowing the step by step approach that was used by the researchers to arrive at data collected. It is also for a reflection on the major steps taken to achieve the purposes set for this research work in the early chapters of the research report. To this end, the following components have been discussed.

3.2 Research Design

There are six major research designs that can be used by researchers [13]. The subsequent paragraph presents the procedure followed to gain precise information for the study. In this research, qualitative research proved to be more appropriate considering that qualitative research is a method of inquiry used in various academic disciplines, commonly in social sciences, in market research and in other disciplines [36]. This method involves analyzing of data such as video pictures, words from interviews, video pictures or objects like an artifact. The objective of doing a qualitative research is to have deeper knowledge of human behavior, as well as, the governing reasons for such behavior. This method of research seeks to investigate the why and the how of making decisions, but not just about when, where and what. Therefore, focus yet smaller samples are required than the larger samples. Conventionally, qualitative research method provides information limited to certain cases that are studied and any other general conclusions are but assertions. Quantitative research methods then applied in seeking empirical supports to the hypothesis. Among the many quantitative research methods, a case study was applied to investigate the current problems of a company which applies a Pulse board to visualize its product development processes. A case study involves intensive analyzing of an individual unit
and emphasizes on developmental factors. Case studies can be explanatory or descriptive [37]. An explanatory case study explores causation in finding underlying principle. The principal might be prospective which involves a criteria established with the cases that fits the criteria or retrospective which involves the criteria established for the purpose of selecting cases from historical events to be included in the study. The choice of a case study as a research method was based on various strengths attributed to using it. Key among them is that it is a strategy that can provide detailed information concerning an event under study because it is a study that lasts for a longer period. Moreover, instead of following certain rigid strict sets of rules and samples in examining few variables, the method of case study involves longitudinal and in-depth examination of an event or a single instance. Case studies, as well provide a definite systematic way of perceiving events, data collection, information analyzing, and reporting of the results. From this, the researchers might gain higher understanding of how something occurred, and what would become important to look to more keenly in future. Although it has been known to have some limitation basing on the fact that results that are obtained from a case study cannot be of much use to the whole population due to the fact that in most cases the person under study may have a disorder, its advantages override its weaknesses. Additionally, according to Dawson, this exploration can be done directly with the use of interviews, observation, etc.; or indirectly by reviewing the reports or documents that exist in the company [38]. As there is no document and report available in the company to investigate, we will do a case study that can provide an allowance for the researchers to observe how the Pulse board is applied to visualize the product development processes, as well as, holding a few interviews with the key users who work with the board. A case study, therefore, stands out as the most appropriate method to be applied in this research.
3.3 Instrumentation

The instrumentation simply refers to the mechanism of data collection. In all, the researcher made use of interview questions, as well as the observation method, in which case there were some interviews with Pulse board expert users who are not from this case. The aims of these interviews were to gather qualitative data about approaches that can be applied in tackling current issues that pertains the use of Pulse boards in global multi-project environment. This kind of data will help broaden our perspective about Pulse board issues, as well as support generalizing the solution to other contexts.
Accordingly, overview of the research design is shown in figure 2. First, the research problem was defined with the help of our supervisor, industrial partner and reviewing the literature. Next,
empirical data was gathered by observing company A and interviews with expert users of Physical Pulse Board. During the interviews, the interviewees were asked several questions controlled by the same set of major questions and only minor differences due to interviewees' backgrounds. The conversations were recorded with audio equipments and taken notes. Furthermore, Feedback on the findings from the subjects who provided the data in the first place was used to validate our finding. Once all desired empirical data was collected and analyzed, they are applied and used in reality by implementing a web-based application (EPB). Agile Methodologies were used in these steps so each feature is developed and validated iteratively. Afterwards, evaluation was done to figure out the usefulness of the developed application. Data and information gained during empirical data and Implementation were validated and verified to maintain fine quality research. As a result this aids us to improve the quality of our study and make possible to examine our thesis. Finally the summary and conclusion are illustrated.

One of the commonly used techniques for collecting qualitative data is the interview [39]. Interviews are sometimes used in combination with observations to clarify things that happened or were said during an observation to elicit impressions of the meeting or other event that was observed, or to collect information on relevant events that were not observed [39]. Therefore, to figure out the real issues both interview and observation were conducted. Observation is another technique commonly used often in case studies [23]. Participant observation, as described in Bogdan and Taylor [40], refers to “research that involves social interaction between the researcher and informants in the milieu of the latter, during which data are systematically and unobtrusively collected.” Therefore, firsthand information and interactions is captured which might not be detected differently [39].
Interpretation of participant observation varies whether the observer is become involved in the activity being observed, or merely the observer is participating and collecting data visibly. To prevent misunderstanding, the term direct observation is mostly employed when researcher is not actively involved in the work being observed [41].
Chapter 4 - Empirical Data Gathering

4.1 Observation

4.1.1 Description of involved company

Company A formulates the standard for high-level creativeness and skillfulness in the field of Mission-Critical Communication. Their activities include network testing (testing and optimization solutions for mobile networks), wireless solutions (customer-specific on-site communication solutions) and security communication (secure, reliable communication solutions for alerts, mobilization and tactical communication). The company was founded in the 1950’s and has 1200 employees worldwide. Their company market place sector involves health care, security facilities and the process and manufacturing industry. They implement solutions intended to meet customized communication requirements based on innovative, reliable technologies

4.1.2 Data Collection

Direct observation was done in this study as observers did not participate in the work being observed. All those who being observed were informed in advanced with the reason of why they are being observed. Awareness help to assure that the observed behavior was normal, for instance that is what regularly happens in the environment being observed, and attendance of observers are not affected their behaviors. This beforehand notice save times and prevents a lot of explaining during observation. Besides, ensuring accuracy of data is the main advantage of
electronically recording the observation. Thus, The observation was recorded, which they were informed of in advanced, so that it make possible to review if any ambiguity exists.

The information collected throughout an observation is eventually recorded in the form of field notes. The notes are not visible to any of those who being observed. Actually, the notes have been kept confidential throughout the study. As a consequence, any impressions, thoughts or ideas have been written without the fear that they might be read by someone who will misread them. These notes are created during the actual observation, during which, what is essential to include were written. Then, shortly after the observation, the notes were augmented with as many details as possible that can be remembered.

4.1.3 Results

A Pulse board is a way to synchronize different business entities. Line organizations, groups, products, departments, divisions, projects and people individual are business entities. Basically Pulse board is used when something need to be synchronized. For instance Pulse board can be employ for the projects that need resources to be allocated or when projects need to be synchronized with other projects.

In other word Pulse board is used for keeping track of the status in projects or line functions. It is a way of coordinate product development. To know there are problems and deviations that would affect not only that specific project but also other projects. Pulse board is a coordination board, a good way to visualize and to find deviations preferably before they are occurring.

Pulse board meeting induce shorter along with less complicated meetings. Instead of long meetings in a seminar room, shorter meetings nearly 10-15 minutes are held usually once a week. Throughout these meetings everybody is standing up in-front of the board and can
thereby visually see and perceive the contemporary state. Pulse board is a cross-functional board which connects all projects with each line organization. Product line is visualized in one axis and line groups are presented in another axis, and this makes a matrix together. A color marker is placed in each square that connects a project and a line organization. This marker could be for instance the color red, yellow, white or green. This marker expresses if there is a problem and the solution is not clear yet (red), if everything is according to plan (green), if there is a problem but the solution is clear (yellow) or if there is no relation between the project and line organization, white.

If there is a deviation, short description (summary) about that deviation will be written on the board. Besides, the detected deviation dates and estimated dates for resolving the deviations will be written on the board. These dates will help to make corrective decisions accordingly.

In addition, if there are reports for deviations, A4 paper report will be attached on the board. These reports provide detailed information about the deviations and it can be used if necessary. Each product line has its own responsible person which is distinguishable by the Physical Pulse board.

Although knowing the rules of Pulse board is necessary, but it is so simple and the rules can be learned easily by just participating in a meeting. Another way or the best way to understand the rules is to talk to responsible of Pulse meeting since that person obviously knows the rules and can elaborate them the best.

There will be just one red button for more than one deviation in each organizational line. This scenario is also true for yellow button as there will be only one yellow button for more than one deviation in each organizational line. But there is a possibility to have red and yellow buttons at
the same time in each field. In contrast it is not possible to have yellow or red buttons at the same
time with green button.

In Lindlöf and Söderberg study coordination and communication found to be the important
metrics in visual planning [7]. The study shows that the ability to coordinate the efficiency of the
task is provided by both the high frequency meetings, and the overview due to the board [7].

4.1.4 Issues related to Pulse board

- Discussion about whether deviation should be red or yellow might happen in the meeting.
  On the other hand the discussion itself is crucial as one important use of Pulse board is to
  identify deviations and discuss them.

- Projects and business entities should be fairly stable; otherwise you just update the board.
  For instance when you have many small projects that changes over time, you need to
  update the board very often.

- Pulse board just emphasizes more on problems which is rather good because it saves time
  but projects that seem to be on plan will not be considered. Therefore only red and yellow
  markers are discussed during the meeting in order to have short and effective stand up
  meeting in front of the Pulse board.

- Physical Pulse board is connected to the analog nature, it is physical and you cannot
  break it down easily, you see the red button but you do not know what the exact problem
  is. If you miss the Pulse board meeting, there is nothing to go back to and understand
  why something has been changed.
There is existing limited space on the physical Pulse board; therefore, just very short description can be written on the board.

In Axeborn & Bjugger study, only red and yellow-colored indicators are discussed during the Pulse meeting [8]. Lindlöf and Söderberg state that the analogue format is underlying both weaknesses and strength of visual planning method [7]. Söderberg indicates that the analogue nature encounter opposition in some cases due to its simplicity and is recognized unprofessional by some people [18]. These finding are in agreement with the results in the current study.

4.2 Interview I

Interview focuses on finding issues and difficulties related to physical Pulse board especially in global environment. In this regard, 5 expert persons were chosen to be interviewed. The interview was done semi-structured with the sufficient flexibility that allows unforeseen type of information to be revealed and gathered. A plainly unstructured interview is often too overpriced to be employed extensively. Semi-structured interviews are characterized by both the interviewer and correspondents engaging in a somewhat formal interview. In this respect, an interviewer has to come up with the interview guide that constitutes questions, as well as topics that should be covered in the conversation following a certain order. Occasionally, the interviewer is guided by the guide following a topical trajectory during the conversation process. Semi-structured interviewing can be the best in cases where the researcher is informed that he/she cannot afford to get another chance to interview the participant [42]. More specifically, it is appropriate in cases where the interviewer just sends out interviewers out to the fields for purposes of collecting data. The semi-structured interviews have various advantages that made them best suitable for collection of data in this study. It is worth noting that semi-structured interviews give clear instructions to interviewers, which ultimately
provide qualitative data that is reliable and also comparable. More often than not, semi-structured interviews are preceded by informal unstructured interviewing, as well as observations. This is done to give allowance to the researchers to develop the understanding of the research topic of interest, which necessitates coming up with the relevant but meaningful questions that are semi-structured. By and large, the opportunity to include the open minded questions, as well as training interviewers helps the interviewers to stay on course during the interviewing process. It also provides better opportunities for identification of new ways through which to see and understand the topic that is at hand. There are other merits for the semi-structured interview that is worth mentioning. Semi-structured interview, as always, are done with a fairly open framework \([42]\). This gives room for a focused, conversational, as well as a two-way communication. In this respect, the semi-structured interview can be used to give and also receive information. As opposed to questionnaires, in which case, detailed questions are often formulated before the real research time, semi-structured interview begin with a somewhat more general topics. In line with this, initially, relevant topics are often identified alongside the possible relationship existing between the topics and other issues including expenses, and availability. This, therefore, makes effectiveness to become a basis upon which more specific questions that do not require prior preparedness to be explored. As if not enough, in a semi-structured interview, is often guided. In this case, some interview guide is prepared beforehand, which end up providing a framework for interviewing. Thus, semi-structured interview were used by many studies \([39]\). These interviews comprise a combination of open-ended and particular questions, created to elicit not only the information prophesied, but also unexpected forms of information \([3, 23]\)
Therefore, semi structured face to face interviews were used where the interviewees were able to speak openly, see Appendix A.

In this way identifying the issues related to using Pulse board and especially in cross functional teams was easier as the interviewees have freedom to emphasize which issues were important for them. According to Bryman and Bell [43] qualitative data is more feasible when gathering sentiment and interpretations when collecting data; hence, this technique was used in this thesis. During interviews one person was leading the interviews while another person was taking notes and observes the reaction of interviewees in order to collect all feeling.

All interview participants were informed beforehand via E-mail in order to make them ready for interview. The interviews were conducted face-to-face and in a silent room. The interviews were recorded, which the interviewees were informed of in advanced, so that it make possible to review if any ambiguity exists and focus more on interview rather than taking notes during the meeting. A summery was made after every interview and if required record materials were reviewed.

Manifesting assessments to subjects, either formally or conversationally, has the increased advantages of making subjects feel part of the procedure, assisting them to perceive how the outcomes were derived, and gaining their support for final assessments [39]. Therefore, feedback on the findings from the subjects who provided the data in the first place was used in this thesis. This method which sometimes is called member checking [4, 23] was used to reconfirm the findings. This method is well suited in the software engineering studies [23].
4.2.1 Interview Validity

Triangulation is a very good tool for verifying the validity of conclusion [44]. The idea behind that is to gather data from different resources to support a proposition. Triangulating interview and observation were used to analyze data. Thereupon, interpreted empirical data from interviews were compared and analyzed based on observation.

4.2.2 Interview Participant Selection

One of significant factor when interviewing is selecting of participants. A random sampling is desirable method if one is studying hundreds of people. To develop a theoretical basis in a much smaller sample size, however, each participant is selected as a part of raw solution. In this occasion, the participants must be selected meticulously. Thereby, purpose sampling was used in this research as the participants were chosen carefully. Purpose sampling is used in situations whereby, “those sampled are relevant to the research questions that are being posed” [43]. The participant selection in this study sought to have variety in its selection; academic research in lean product development and visual planning, overall experiences year in using physical Pulse board and experience of using physical Pulse board in global environment. All of these criteria were significant to achieve a wide variety of experts.

4.2.3 Conclusion of Interview

Physical Pulse board is simple and provides good overview but, the awareness that creates with the Pulse board is the main advantage of using it. It is also easy to understand the structure of Pulse meeting and tool. Without physical Pulse board, a lot of time will be spent to discuss who are involved in each specific projects, whether that particular project is going well or not, but
with using the Pulse board, a lot of time will be saved as it provide good overview and only problems will be discussed.

The main aims of the interviews were to figure out the issues and difficulties of using Pulse board, therefore its related issues are listed below:

- Inability to support distributed teams. Every Pulse meeting has to gather people who are co-located – they have to be physically at the same place and that would be problem in distributed teams. Synchronization would be difficult as for instance there exist one master board and a copy of it in two different locations, so when a master board is changed, its copy need to be changed.

- Histories of Pulse board meeting are not kept. Therefore, it makes difficult to track back and see what happens heretofore. For instance if a group manager wants to see who were overloaded and who were under loaded to plan participation in new projects.

- The physical Pulse board should be put somewhere that people do not walk too much by, otherwise the risk of moving something from the board is high.

- It is not possible to write on most Pulse boards. Even when it is possible there are limited spaces available on the boards.

- Availability problem - The PPB is not available anytime and even when it is available, understanding what have happened during the Pulse meeting is rather difficult if you miss the meeting. Therefore, participating in the meeting is crucial.

- It is difficult for color blinds to distinguish colors easily in the physical Pulse board.

- Language problem - This may cause a problem in distributed teams when various teams participate in the meeting from two or more different countries. This is not a big issue but the risk of misunderstanding still exists.
There are various Pulse boards in a company and synchronization of the boards is hard or time consuming. Some boards are interconnected, so when one board is changed, the related boards should also be changed which is done manually by responsible person right now (see Appendix B).

Hiding the deviations – Although Pulse board create awareness, but someone may hide the problem and pretend that everything is according to plan. Thus, it is not just the Pulse board that provide awareness, it is also the culture connected to it.

It was claimed by Söderberg and Alfedsson that the ability to equalizing the workload is restricted if the competences differ a lot in a team. Project members may see this function as a control system; as a consequence, they may be reluctant to state planned finish dates and other necessary information needed in this method [17].

In agreement to the result of current study; in Lindlöf & Söderberg; Sebestyén and Söderberg studies; difficulties to track causal link between activities, difficulties working with distributed teams and difficulties of keeping historical data found to be the major difficulties of applying Physical Pulse board [7, 16, 18].

4.3 Interview II

Observation and interviews were done to find issues related to PPB especially in global environment. Afterward another set of interview was conducted with the focus to find how the detected issues can be resolved especially with the help of the web-based application.

In this regard 5 expert persons were chosen to be interviewed. Likewise the first set of interviews, the second set of interview was done semi-structured with the sufficient flexibility
that allows unforeseen type of information to be revealed and gathered. A plainly unstructured interview is often too overpriced to be employed extensively. Thus, semi-structured interview were used by many studies [39]. These interviews comprise a combination of open-ended and particular questions, created to elicit not only the information prophesied, but also unexpected forms of information [39]. Therefore, semi structured face to face interviews were used where the interviewees were able to speak openly, see Appendix C.

4.3.1 Interview results

In this part the solution which was mentioned by experts for solving the detected issues are provided.

- Inability to support distributed teams

There are different ways to address this issue. Telephone conferencing is one way that is used by some companies to communicate with remote parties who works in different locations. Video Conferencing is another way that is recently employ by different companies to facilitate communication in cross functional teams. Video conferencing can bring people at different sites together by concurrent two-way audio and video transmission. In addition meeting activities that transmit visually, allied videoconferencing technologies could be used to exhibit information on the Pulse board.

Excel sheet is used to handle meeting between distributed teams. Prior to the meeting someone who is responsible of updating the excel sheet, checks the Pulse board and update excel sheet. Remote parties have access to the excel sheet so that to track the statuses of Pulse board. During the Pulse meeting, remote parties attend the meeting via telephone conferencing, video
conferencing, etc. and when a change happens at the physical board the responsible person of excel sheet update it simultaneously.

Video cameras can also be used to enhance coordination in global environment. Video cameras can be set in a physical Pulse board room. Thus, during the meeting, it looks at the board and registering everything on the board and displaying them in other sites.

The best solution to enhance coordination between different parties that was mentioned by the experts during interview was to use electronic Pulse board that automatically maps the Pulse board by one way around the other in different locations.

- Inability to store history

Taking photos of Pulse board every time and have digitally stored them is one common way that is used to store history of Pulse board. There are some difficulties to apply this technique. First, the process needs to be done manually. Second and the most important drawback of store history of Pulse board with taking photos is that tracking of statuses are rather hard. It is not possible to get history like good reports; sometimes it needs to go through and look at many of pictures to figure out what you really need.

Storing the history of Pulse board at an excel sheet is another way that are employed extensively. Likewise taking photos of Pulse board, storing the history at excel sheet has some drawbacks like tracking difficulties. It is quite complicated to trace the history due to the fact that it is not possible to get the history like a good report. Thus, if you are looking for specific information you should look at some excel sheet to find out the information that you are looking for. Excel sheet is file based; therefore, subversion system or type of versioning like share point is needed.
Besides, from information management point of view it is not secure or good way of managing information.

Database system can be used to keep the history and manage information in a very good way. The stored data is managed to some level of quality in terms of availability, usability, accuracy and resilience. Database system provides the ability to query and get the specific report whenever needed. Thus, this is the better solution to keep history compared with taking photos and excel sheet.

Database can also be used with different technologies and method to enhance storing history and coordination between cross functional teams. For instance, optical tracking system can be located in the Pulse board room and while it register the information on the board, it can store them in the database as well.

The best solution that was mentioned by interviewees is to use electronic board with database behind it can be used not only to improve coordination but also to store the history in to some degree of quality.

- Accidentally wipe the physical Pulse board

   It is not a big issue due to two reasons. First, normally responsible persons write the information and summary of what have been changed during each meeting. Second, pictures are taken from the Pulse board meeting every time or the history of the Pulse board might kept in a excel sheet. This information can be used in a case if everything is lost on the board. Therefore, if something wipe from the board, it can be easily distinguished manually by just looking at the board. For instance if there is one red button and one yellow button in one specific field then the protocol says that there should exist one deviation summary for each deviation, thus there should exist
two deviation summary. In this case if one red button wipe from the board unintentionally, it is distinguishable manually by looking at the protocol and see how it should look like.

- Limited space on the physical Pulse board

There is no any good solution for limited space on the board. Responsible persons will take notes during each meeting so that there is no need to write everything on the board, but if more space are needed on the board therefore bigger room and board should used.

The documentations are usually kept on the paper as a form of report and it is not always possible to put the reports on the board. The responsible person must know the information and detail of the relevant deviations and if some unexpected thing happens, for instance if the responsible person died, and just he/she have the reports on the paper then in the Pulse meeting, that deviation will be discussed and if nobody knows what was the problem, hence finding the real problem in this case is rather hard.

There is no restriction on data base system to link to other kinds of documents; in a consequence it is possible to connect deviations to reports. In addition, data base provides good traceability like versioning system or Product Data Management (PDM) system.

- Availability problem

The PPB is not available all the time and even when it is available, understanding what have happened during the Pulse meeting is rather difficult. Responsible persons normally take notes during the PPB meeting so if they forget anything or need to review something then their notes can be reviewed. In addition they can take advantages of photos or excel sheet that are available for them. But if PPB meeting is missed by someone in a case of sickness or other unavailability
problem, he/she could look at the excel sheets or photos if available, if not call someone and ask him for further information.

Data base system can be employed instead of photos or excel sheet to enhance many issues including availability problem. There is a possibility within data base system to see what has changed during the meeting and if the changes related to you or affect the product line of which you are responsible for.

Electronic Pulse board with the data base system behind it is very nice solution to eliminate this issue. It solves this issue to some extent because everything related to Pulse board is not documented; hence attending the meeting is the big part of the Pulse board.

- Difficulty for color blind to distinguish different colors
  For resolving this issue symbols can be used in physical Pulse board or electronic pulse board as well. In a consequence color blind can distinguish different colors not by different colors but by various symbols.

- Language problem
  It is more about meeting, cultures and collaborations; it is not really connected to the Pulse board. Term of deviation may mean differently in different companies.

- Different board synchronization
  Synchronization of different board is done manually by someone who is responsible to update different boards according to specific rules of organizations.
  
  It is possible to electronically manage board synchronization by linking or mapping between boards. In this way when something has changed in a specific board, other related boards will be updated automatically according to rules. Although it is quite complex to aggregate and update
different board for instance in the project alpha board, there are five green button, two red button and one yellow button but in the other board you have just one field to specify project Alpha status so there has to be a rule to map many point to one point (in this case map 8 point to 1 point).

- Hiding the deviations

Hiding the deviations is quite common. It is more company culture than geographic culture. Companies should make sure not to promote the behavior that is bad for company. For instance, if organizations promote quick fixes, people who find deviations and solve them very quickly will be rewarded, and then someone may hide the problems for sometimes and when he/she has announce the deviation when has the solution for it. In contrast good behavior should be promoted, for example people should flag the deviation as soon as possible and make sure that the deviation is not affected other projects. It is more important to go from red deviations to yellow ones than going from yellow deviations to green buttons as yellow buttons means that there are plans to solve the issues. Then if red deviation is detected, its status should change quickly to yellow by finding a good solution for that issue in addition to make sure that the solution is in line with other projects. It means that the solution should be in a way that not only solve that issue but also consider other projects not to promote other issues for them later on.

In tandem with the interviewees solution to resolve physical Pulse board issues, Axeborn and Bjøgger study states that some companies like Swerea IVF take advantageous of using computer systems with a projector in global environment to get the same effect as a physical board [8]. The study indicates that a Swedish company “Ascom” is using a conference phone to get people who are in other places participating in the meeting [8]. Moreover, the study expresses that in order to
solve global issues of visualization; SKF Company is using web-cameras. However, they claimed that they have seen no good example of companies who make visualization global [8].

4.3.2 Results and Discussion

A Pulse board is a way to synchronize different business entities. Line organizations, groups, products, departments, divisions, projects and people individual are business entities. Basically Pulse board is used when something need to be synchronized. For instance Pulse board can be employed for the projects that need resources to be allocated or when projects need to be synchronized with other projects.

In other words, Pulse board is used for keeping track of the status in projects or line functions. It is a way of coordinate product development. To know where there seems to be problems and deviations that would affect not only that specific project but also other projects. Pulse board is a coordination board, a good way to visualize and to find deviations preferably before they are occurring.

Pulse board meeting induce shorter along with less complicated meetings. Instead of long meetings in a seminar room, shorter meetings nearly 10-15 minutes are held usually once a week. Throughout these meetings everybody is standing up in-front of the board and can thereby visually see and perceive the contemporary state. Pulse board is a cross-functional board which connects all projects with each line organization. Product line is visualized in one axis and line groups are presented in another axis, and this makes a matrix together. A color marker is placed in each square that connects a project and a line organization. This marker could be for instance the color red, yellow, white or green. This marker expresses if there is a problem and the solution is not clear yet (red), if everything is according to plan (green), if there
is a problem but the solution is clear (yellow) or if there is no relation between the project and
line organization, white.

If there is deviation, short description (summary) about that deviation will be written on the
board. Besides, the detected deviation dates and estimated dates for resolving the deviations will
be written on the board. These dates will help to make corrective decision accordingly.

In addition, if there are reports for deviations, A4 paper report will be attached on the board.
These reports provide detailed information about the deviations and it can be used if necessary.
Each product line has its own responsible person which is distinguishable by the Physical Pulse
board.

Although knowing the rules of Pulse board is necessary, but it is so simple and the rules can be
learned easily by just participate in a meeting once. Another way or the best way to understand
the rules is to talk to who is holding the meeting since that person obviously knows the rules and
can elaborate them the best. For instance, there will be just one red button for more than one
deviation in each organizational line. This scenario is also true for yellow button as there will be
only one yellow button for more than one deviation in each organizational line. But there is a
possibility to have red and yellow buttons at the same time in each field. In contrast it is not
possible to have yellow or red buttons at the same time with green button.

In so far as pulse board meetings are concerned, discussion about whether deviation should be
red or yellow might happen in the meeting. On the other hand, the discussion itself is crucial as
one important use of Pulse board is to identify deviations and discuss them. Projects and business
entities should be fairly stable otherwise you just update the board. For instance when you have
many small projects that changes over time, you need to update the board more often. Pulse
board just emphasizes more on problem which is rather good because it saves time but projects that seem to be on plan will not be considered. Therefore only red and yellow markers are discussed during the meeting in order to have short and effective stand up meeting in front of the Pulse board. Physical Pulse board is connected to the analog nature, it is physical and you cannot break it down easily, you see the red button but you do not know what the exact problem is. If you miss the Pulse board meeting, there is nothing to go back to and understand why something has been changed. There is existing limited space on the physical Pulse board, just very short description can be written on the board.

4.4 Validity and Reliability

4.4.1 Internal Validity

Internal validity refers to factors which may influence the result [45]. Interviewees lacking knowledge or competency could be a thread to this study. To reduce this thread purpose sampling was used in this research as the participants were chosen carefully. Thereby, academic research in lean product development and visual planning, overall experiences year in using physical Pulse board and experience of using physical Pulse board in global environment were important factor to choose participants. In addition, different source of study for instance observation and interviews were combined to triangulate the data which in return cause greater internal validity.

4.4.2 External Validity

External validity refers to threads that restrict the study to be generalized [45]. To mitigate this thread we select our subjects from different categories like researchers, industries and experts.
This helped us to gather data from different viewpoints. Moreover, the involvement of a thesis advisor makes the outcome of the study more generalized.

4.4.3 Construct Validity

Construct validity refers to generalizing the outcome of the research to the theory or concept behind it [45]. The interpretation of interviews could be a thread to this study. To alleviate this thread member checking methods were used in this study [39]. Therefore, feedback on the findings from the subjects who provided the data in the first place was used in this thesis.

4.4.4 Conclusion Validity

Conclusion validity refers to threads that influence the ability to reach a conclusion from the research [45]. Searching for the specific results could be a thread to conclusion validity. To mitigate these threads semi-structured interviews were used with the sufficient flexibility that allows unforeseen type of information to be revealed and gathered. In addition, evaluation of implemented software through a workshop makes the conclusion validity of the study trustworthy.
Chapter 5 - Implementation of Web-based Application

Face-to-face meeting have traditionally been important to participatory procedures. But, since face-to-face meeting are not feasible for global or large-scale projects, where different teams/groups from various location attend the meeting, there is a need for innovative substitute and world-wide-web supply a proper infrastructure for this aim. Brabham claims that using a web is a good solution to improve existing participatory methods [46]. Ability to provide speed, accessibility, interactivity and the ability to accept other media makes world-wide-web ideal medium for facilitating creative participation. Problems causes by differences in space and time diminish by using the World-wide-web [46, 47]. Temporal and special distance among different teams/locations is decreases by web-based technology. It provides the capability for more interaction and participation in the projects.

Nowadays, digital visualization tools are greatly practices around the globe by different companies. Accessible visualization tools, however, are neither integrated nor efficient enough or too expertise demanding and thus not entirely fulfilling the qualities needed. There is not any implemented application which is optimally effective, flexible, powerful, easy to use and understand and distributed so as to be conveniently used within different companies.

Most of agile project planning is supported by existing tools. However, they are not fully support collaborative interaction [35]. Besides, these tools do not fulfill the requirement in LPD. One aspect of LPD is to have short meeting. Existing tools are complicated and hard to understand. They are used for multiple purpose and they are not good enough for 15 minutes meeting that just issues are highlighted and discussed.
Furthermore, add too much information to the board makes it too complicated. It is important and beneficial to keep the boards simple in order to heighten the level of comprehending among viewers and to simplify the usage. It is necessary that the boards have color signals, but too much signals reduce its clearness. The employees are supposed to understand the board easily.

Nowadays, digital visualization tools are greatly practices around the globe by different companies. Accessible visualization tools, however, are neither integrated nor efficient enough or too expertise demanding and thus not entirely fulfilling the qualities needed. The tool should make it possible to coordinate units and activities efficiently, leading to individual, groups and managers improvement. Group members should easily understand a situation that need their intelligibility, or intervene when fellow workers have problems. However, it is partially supported by most existing tools.

There is not any implemented application which is optimally effective, flexible, powerful, easy to use and understand and distributed so as to be conveniently used within different companies. The big problem that companies face while implementing LPD is that many LPD tools are very obscurely illustrated in the literature [48]. We can conclude that there is no best way when implementing visualization according to LPD as every company is unique. Therefore, companies cannot copy and paste from other companies. Thereby, we try to create a web-based application eliminate the restriction of existing tools, adjusted to Repos AB and by taking advantages and limitation of APDT (Agile Planner for Digital Tabletop).
5.1 User Stories

Given that communication is very important in software requirement, there is a need to make sure it is effective. Those who want new system or software need to communicate with those who will implement new software for them. Different people with different perspective affect succeed of software including customers, users, domain experts, analysts, etc. But if any of them dominates the communication the project loses. When the developers dominated the communication they used technical gobbledygook instead of business language and they lose the possibility of what is really needed by listening. When the business side dominated the communication they focus more on the delivery time with little concern of whether developers understand what is really needed and if they are capable of implementing the functionality in that time [48].

Therefore, the important factor is to find a way to work together so that neither side dominates and thus the resource allocation becomes a shared problem. When the process of resource allocation is completely done by one side the projects fail. When customers or users set to work on resource allocation, there is a long conversation at the beginning during which features are gradually removed from the project. Then when finally the software is delivered, it seems that it has less functionality that the diminish set that was recognized. If the resource allocations are done by developers and usually in the form of being told to be done by that time, some decisions will be taken which needs the customer or user to participate, they may partly implement a feature or they may trade quality for additional features [48].

We cannot precisely estimate a software development projects as the users and customers see the early version of software, they come up with new thoughts and their minds change. The software is intangible therefore, is hard for developers to estimate how long things take to implement.
Because of these and other factors it is very hard to have a PERT chart and exhibit all things that should be done on a project [48].

So it is necessary to make decisions based on information at hand and do it often. Rather than doing all decision at the beginning of the project it is good and worthy to make decisions during the project. Therefore, a process is needed to get information as soon as possible and frequently. And this is the main reasons that user stories are used.

What is user story?

Stated functionalities that are valuable for either customer or purchaser of the software or system is called user story [48]. Aspects of user stories are described below [48]:

- A written statement of user story utilize for planning
- Conversation about stories that reveal the detail of stories
- Test and document the detail of stories

On the other hand, in agile software development, requirements are gathered from simple knowable estimation to the final requirements, and then continue to gather more detailed information during the project. In this way the requirements will be as precisely and functional as the final product itself [49].

User stories are a central part of agile methodologies which define what is need to be build in the software project [50]. User stories are prioritized by the customer to show which are the most important for the project and then will be divided to different tasks and appraised by developers [50].

Besides, some benefits are applying user stories are listed below [50]:
- Being short. User stories indicate small pieces of business value that can be implemented in short time.
- Little maintenance is needed.
- Allowing systems to split into small increments.
- Enable developers and customer representatives to communicate about requirement throughout the project.
- Estimate development effort will be easier [50, 51].
- Just take into account at the time of use
- The most valuable part of the software will be implemented as user stories demand close customer communication.
- User stories are suitable for projects where users and customers do not know what they really want at the beginning.
- User stories postpone collecting details (contain aim level story) [51]

As a result user stories are used to gather information about what the customer is really want.

5.2 User stories for pulse board

User stories of EPB are listed below (for more detail see appendix D):

- US1. As a manager, I want to be able to see in which organizational line deviation exists.
- US2. As a manager, I want to have short description (summary) of each deviation.
- US3. As a manager, if there are deviations, I want to be able to have the detected deviations dates and estimated dates for resolving them to make corrective decisions accordingly.
- US4. As a manager, I want to see the approaches to tackle detected deviations.
- US5. As a manager, if there are reports for deviations, I want to see them to have better understanding of issues.
US6. As a manager, I want the amount of information that is shown on the screen be adjusted in a readable way.

US7. As a manager, I want the system to store history, so that the information can be tracked.

US8. As a manager, I want the system to have different authentication levels.

US9. As a manager, I want to have the possibility to mark upcoming changes.

US10. As a manager, the system should have the capability of defining the responsible person to confer the responsibility of each product line.

US11. As a manager, I want to see how many deviations in each organizational line exist.

US12. As a manager, I want to be able to see the deviations when the buttons are clicked.

US13. As a manager, I want to be able to add deviations.

US14. As a manager, I want to be able to delete deviations.

US15. As a manager, I want to be able to change deviations.

US16. As a manager I want to be able to add, delete or modify detected and estimated dates of resolving deviations.

US17. As a manager, I want to see time stamping/history of board statuses. [Related to US7]

US18. As a manager I want to have the ability to add, remove or edit different rows or columns.

US19. As developers, we want to have just the information that needed in the add form.

US20. As a manager I want to have the following information for each deviation:

US21. As a manager, I want the system to have feature of keeping comments on deviations.

US22. As developers, we want the application to automatically refresh only on things that have changed.

US23. As a manager, I want to have the ability to edit the following information for each deviation.
5.3 Prioritization

5.3.1 Introduction

Requirements prioritization of WPS (web-based Pulse board system) using the 100-dollar method are presented here. Requirements are evaluated in terms of cost and value and a number of other factors such as Importance and Penalty. A total of seven release plans are then developed that include a set of prioritized requirements suitable for each product release. Finally, the 100-dollar prioritization technique is explained in terms of its motivation and applicability to the system.

5.3.2 System Requirements

Table 1 outlines the requirements for the WPS. Additionally, the specification addresses a number of non-functional requirements such as usability, security and portability. We realize that non-functional requirements are rather useless without the functional requirements and can be in conflict with each other while affecting a whole set of system functions. Therefore, in analyzing the priority, value and cost for each requirement we assumed that non-functional requirements are within the functional requirements and shall be implemented as part of the specification and acceptance criteria for each requirement description.
### User Story ID | Requirement Description | Dependency
--- | --- | ---
US1 | Existing deviations | US7
US2 | Summary of deviations | US7
US3 | Detected and Resolved Deviation date | US7
US4 | Approaches to tackle detected deviations | US7
US5 | Link to reports | US7
US6 | Readable amount of information | US7
US7 | Store history | US7
US8 | Authentication and access permission | US7
US9 | Mark upcoming changes | US7
US10 | Responsible person | US7
US11 | Numbers of deviations | US7
US12 | Deviations and related buttons | US7
US13 | Add deviations | US7
US14 | Delete deviations | US7
US15 | Change deviations | US7
US16 | Add, delete or modify detected and estimated of resolving deviations | US7
US17 | Time stamping/history of board statuses | US7
US18 | Admin functions to add, remove or edit rows/columns | US7
US19 | Improvement of add forms | US7

Table 1: System Requirements

#### 5.3.3 Requirements Prioritization

The prioritization technique chosen for WPS is the 100-dollar method whereby project stakeholders as well as the project manager are given 100 imaginary points to allocate to the entire set of requirements. Each participant is given a weight factor that is adjusted based on their technical influence and prior experience. Units may be presented in terms of value or cost and are used to calculate the prioritization for each participant given their weight. The calculated priority in turn is used to assess the requirements based on other aspects, such as Importance and
Penalty. We have defined Importance in terms of strategic urgency for the system while Penalty is defined as consequence if the requirement is not fulfilled.

The results are finally evaluated on a ratio scale.

### 5.3.3.1 Prioritization for Value

Steps carried out are:

1. Requirements and points are distributed to all participants.

2. Weight factors determined as follows:
   - Stakeholder #1: 0.15
   - Stakeholder #2: 0.3
   - Stakeholder #3: 0.2
   - Project Manager: 0.35

3. Importance and Penalty weight factors are applied:
   - Importance: 0.7
   - Penalty: 0.3

4. Points are distributed by participants on a ratio scale.

5. Priority for each requirement is calculated as:

   \[
   P(R_x) = \left[ R_P(S_1) \times W(S_1) \right] + \left[ R_P(S_2) \times W(S_2) \right] + \left[ R_P(S_3) \times W(S_3) \right] + \left[ R_P(S_4) \times W(S_4) \right]
   \]

6. Importance for each requirement is calculated as:

   \[
   I(R_x) = P(R_x) \times WI
   \]
7. IP for each requirement is calculated as:

\[ IP(Rx) = I(Rx) + [P(Rx) \times WP] \]

8. Results are displayed on a ratio scale

Appendix E shows the requirements prioritization by value and Appendix F depicts the prioritized requirements by value on a Ratio Scale.

5.3.3.2 Prioritization for Cost

Steps carried out are:

1. Requirements and points are distributed to all participants.

2. Weight factors determined as follows:
   1. Stakeholder #1: 0.15
   2. Stakeholder #2: 0.3
   3. Stakeholder #3: 0.2
   4. Project Manager: 0.35

3. Points are distributed by participants on a ratio scale.

4. Cost for each requirement is calculated as:

\[ C(Rx) = [RC(S1) \times W(S1)] + [RC(S2) \times W(S2)] + [RC(S3) \times W(S3)] + [RC(S4) \times W(S4)] \]

5. Results are displayed on a ratio scale.

Prioritization for cost is shown in Appendix G and Appendix H depicts requirements prioritization for Cost on a Ratio Scale.
5.3.4 Cost vs. Value Comparisons

Appendix I compare the cost and obtained value for each requirement. The table is sorted in the custom descending order of the highest value and lowest cost. For example, requirements US1 and US6 provide the same value points, but requirement US1 costs less than US2.

5.3.5 Release Plans

Release plans are developed based on the Cost vs. Value comparison table as well as the dependency between requirements that configure the order of development. Requirements that provided the highest value with the lowest cost will planned for the first release and subsequently those with the lowest value yet the highest cost will scheduled released. There are no Cost constraints for each release, but the objective was to disallow the Cost constraint to exceed 30% for each release. Release plans are shown in table 2.
<table>
<thead>
<tr>
<th>Requirement ID</th>
<th>Release Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Release 1</td>
</tr>
<tr>
<td></td>
<td>Value</td>
</tr>
<tr>
<td>US1</td>
<td>15</td>
</tr>
<tr>
<td>US2</td>
<td></td>
</tr>
<tr>
<td>US3</td>
<td></td>
</tr>
<tr>
<td>US4</td>
<td></td>
</tr>
<tr>
<td>US5</td>
<td></td>
</tr>
<tr>
<td>US6</td>
<td>15</td>
</tr>
<tr>
<td>US7</td>
<td></td>
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<tr>
<td>US8</td>
<td></td>
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<td>US9</td>
<td></td>
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<td>US10</td>
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<td>US11</td>
<td></td>
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<td>US12</td>
<td></td>
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<td>US13</td>
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<td>US14</td>
<td></td>
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<td>US15</td>
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<td>US16</td>
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<td>US20</td>
<td></td>
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<tr>
<td>US21</td>
<td></td>
</tr>
<tr>
<td>US22</td>
<td></td>
</tr>
<tr>
<td>US23</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 2: Release plans overview

5.3.6 Motivation for Prioritization Technique

In choosing the most suitable technique, we chose the 100-dollar method for its simplicity and low learning curve. The calculations are quite simple and easy to understand for all stakeholders as opposed to Analytical Hierarchy Process (AHP), where if chosen, with our set of 23 requirements could have created a very large and unmanageable matrix grid. 100-dollar method is also an effective tool when analyzing requirements for both customer importance and cost
aspects, such that it can involve project managers and other stakeholders in the voting process. We also realize that not all stakeholders are equally deemed important by the project sponsor and using the 100-dollar method allowed us to assign weights to each participant based on the prior experience and domain expertise [52].

**5.4 Overview of Developed web-based application**

As stated above Pulse board is a way to synchronize different business entities. Line organizations, groups, products, departments, divisions, projects and people individual are business entities. Basically Pulse board is used when something need to be synchronized. For instance Pulse board can be employ for the projects that need resources to be allocated or when projects need to be synchronized with other projects.

Important deviations are visualized at the Pulse board. Every issue is examined during the meeting, the problems will be explained and appropriate action will be made. If it cannot be solves with that level e.g. project level, it is moved down or up to the next level, producing a flow in the organization. It makes more effective utilization of resources, produces a transparent organization, extend flexibility and improved understanding.

In other word Pulse board is used for keeping track of the status in projects or line functions. It is a way of coordinate product development. To know there are problems and deviations that would affect not only that specific project but also other projects. Pulse board is a coordination board, a good way to visualize and to find deviations preferably before they are occurring.

Pulse board meeting induce shorter along with less complicated meetings. Instead of long meetings in a seminar room, shorter meetings nearly 10-15 minutes are held usually once a week. Throughout these meetings everybody is standing up in-front of the board and can
thereby visually see and perceive the contemporary state. Pulse board is a cross-functional board which connects all projects with each line organization. Product line is visualized in one axis and line groups are presented in another axis, and this makes a matrix together (see figure 3). A color marker is placed in each square that connects a project and a line organization. This marker could be for instance the color red, yellow, white or green. This marker expresses if there is a problem and the solution is not clear yet (red), if everything is according to plan (green), if there is a problem but the solution is clear (yellow) or if there is no relation between the project and line organization, white.

If there is deviation, short description (summary) about that deviation will be written on the board. Besides, the detected deviation dates and estimated dates for resolving the deviations will be written on the board. These dates will help to make corrective decision accordingly.

In addition, if there are reports for deviations, A4 paper report will be attached on the board. These reports provide detailed information about the deviations and it can be used if necessary. Each product line has its own responsible person which is distinguishable by the Physical Pulse board.

Although knowing the rules of Pulse board is necessary, it is so simple and the rules can be learned easily by simply participating in a meeting once. Another way or the best way to understand the rules is to talk to who is holding the meeting since that person obviously knows the rules and can elaborate them the best. For instance, there will be just one red button for more than one deviation in each organizational line. This scenario is also true for yellow button as there will be only one yellow button for more than one deviation in each organizational line. But
there is a possibility to have red and yellow buttons at the same time in each field. In contrast it is not possible to have yellow or red buttons at the same time with green button.

Figure 2 depict the running example of EPB namely “Trunk”. EPB were designed and implemented in a way that never exist full screen. Thereby, any pop-up windows will appear within the main window.

<table>
<thead>
<tr>
<th>Product Line</th>
<th>Quality</th>
<th>Supply</th>
<th>Yield</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALXN</td>
<td></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
</tr>
<tr>
<td>APL</td>
<td></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
</tr>
<tr>
<td>BNS</td>
<td><img src="#" alt="Yellow" /></td>
<td><img src="#" alt="Yellow" /></td>
<td><img src="#" alt="Yellow" /></td>
<td><img src="#" alt="Yellow" /></td>
</tr>
<tr>
<td>KALN</td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
</tr>
<tr>
<td>LSKT</td>
<td></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
</tr>
<tr>
<td>LUC</td>
<td></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
</tr>
<tr>
<td>NSNF</td>
<td></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
</tr>
</tbody>
</table>

Figure 3: Trunk
Numbers of deviations are shown in each field if applicable. For instance, there are two deviations in the field related to ALXN and Supply as depicted in figure 3. If the field is clicked a new window will pop-up which shows the existing deviations. As figure 3 and figure 4 depict, desire deviation can be chosen in order to see its details.

Figure 4: List related deviations
<table>
<thead>
<tr>
<th>Product Line</th>
<th>Quality</th>
<th>Supply</th>
<th>Yield</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALXN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BNS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KALN</td>
<td><img src="red" alt="Cross" /></td>
<td><img src="red" alt="Cross" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSKT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LUC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSMF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![List of Deviations (ALXN / Supply)](image)

- **204: Resource Shortage**
  - Deviation type: red
  - Responsible: Navid
  - Detected date: 2012-05-22
  - Due date: 
  - Reports: ![Folder](image)

**Figure 5: List related deviations**
It is possible to modify the deviation by clicking on the edit button (figure 4). Afterwards, “Modify Ticket” (see figure 5) need to be clicked in order to pursue editing operation. It is also possible to add comments to a deviation when creating or editing the deviation (figure 5 and figure 6).

![Figure 6: Edit deviations](image)
Figure 7: Edit deviations
There is a possibility to resolve the deviation as “fixed”, “invalid”, “wontfix”, “duplicate” and “worksforme” which will set the resolution and next status will be 'closed'. It is also possible to reassign the deviation to another person (figure 7).

Figure 8: Resolve deviations
As shown below reports can be easily shown here by just clicking on them.

Figure 9: Report
The application has the ability to add different deviations including red, yellow and green. When add button is pressed, a new window will pop up that allow adding new deviation. As seen in figure 9, summaries about the deviation can be written. It is also possible to write long description about the deviation that you want to add. Different type including red, yellow and task (task means green; it indicates that everything is according to plan) can be chosen from the drop-down list.

![Add deviations](image)

Figure 10: Add deviations
It is possible to indicate the owner of the deviation, a person who reports this deviation. In addition it is possible to select priority of the deviation among blocker, critical, major, minor and trivial. The system allows you to specify “Due Date”, the date that you estimate that the deviation will be solved (see figure 10).

![Image of deviation creation interface]

**Figure 11: Add deviations**
Furthermore, there is the capability to add files to your deviation if needed in order to have more detailed information about the deviation. If “I have files to attach to this ticket” is checked (figure 10), then a new window will pop up that allow you to attach file to the deviation (figure 11).

![Figure 12: Attach file to the deviation](image)

```plaintext
Figure 12: Attach file to the deviation
```
Minus button is designed to remove the specific deviation. By clicking on this button, a list of all deviations related to that product line is shown, and arbitrary one can be selected and removed (figure 12).

**Figure 13: Close deviations**
In order to prevent unwanted deletion of deviations, a confirmation window will be pop up and will ask you if you are sure that you want to close the deviation. If you click “Yes”, the deviation will be closed otherwise the deviation will remain on the system. It is valuable to indicate that red color dominates yellow or green color. Therefore if we have both red deviation and yellow deviation in one field, red color will be shown on the background of the field with the symbol related to red color. When removing a deviation if there is other red deviation, the field will be kept red but if there is not any red deviation and there is yellow deviation, the color will change to yellow automatically. If we remove a yellow button and there is not any other yellow or red button, it means everything is according to plan and the background color of that field will be changed to green. It is also good to mention that if there is no relation between two entities the background color will be white (figure 13).

![Figure 14: Close deviations](image-url)
Chapter 6

6.1 Workshop

Evaluating and monitoring a program is important to determine if it works as well as providing support for further developing. It is also provide useful feedback regarding whether it is appropriately developed for target population or there are concerns that need to be taken into account. The result will aid us to figure out the weaknesses and strengths of EPB.

Resource shortage is one of the restrictions which every evaluation face to, however, simple and well-designed evaluation can be as effective as a more complicated one [53]. Thereby, developed web-based application was evaluated and analyzed through a workshop with David Hellström, and Dr. Amer Ćatić who are Lean Product Development Specialist.

The workshop was conducted face-to-face in a separate, quiet room. Except for incidental interruptions by an outsider (however the room was booked beforehand). The atmosphere was free of disturbance during the interviews. At the beginning of workshop, EPB were demonstrated by the researchers. Afterward some important features were reviewed again and discussed. The only misunderstanding during the workshop was the meaning of the white color which was clarified by researchers that it means there is no relation between two entities. Every aspects of EPB like completeness, graphical user interface (GUI) and advantages and disadvantages were discussed and evaluate during the workshop which lasted 2 hours.

6.1.1 Functionality

It was claimed by one of the evaluator that it is very beneficial to see how a particular issue has solved. Thus, it is good to have this feature built in the application. If someone e.g. product manager has an issue in one area and he/she puts the red or yellow deviation on the board and
that issue has been solved. Thereby, the product manager needs to know how that issue was solved, for instance if there was resource conflict/shortage related to that issue.

Dates, where issues are reported on the board, are very important. Old issues should get high priority and definitely need to be considered first. That was a good point mentioned during a workshop, however, with the issue management system in the backend; this feature can be added to the EPB easily.

There are a lot of problems that someone may face in one project and if this is beyond the control of the project team and they cannot solve them themselves; then, they need to escalate that problem/issue. For instance if there is resource shortage, the project is dependent from other cycle, etc.

6.1.2 Completeness

The important idea behind digitalizing board is that it needs to be able to connect various boards. If one issue is documented in one board that issue should transfer easily to another board so there is no need to have manual connection in between. The idea of connecting various boards easily is one of the points that are needed in practice. It is needed in practice especially when you have people working in different areas or locations.

There are some rules in some companies say that responsible persons of an entity should agree before a field is highlighted. The person who is responsible for a product line is not allowed to change his/her responsible line until he/she talks with the person who is responsible to that entity. For instance if someone is responsible for APL and wants to change the Supply field to red, he needs to talk with a person who is responsible to the Supply. In this regard, there would
be no surprise when going to the pulse meeting. Accordingly, the numbers of deviations will be probably eliminated as well (see figure 14).

![Figure 15: Example of Pulse board](image)

One of the solutions for the problem stated above could be having work flow regarding the issues. Someone initiated the work flow in our case APL responsible person, and the work flows go to the other responsible person who is in our example a person who is responsible to Supply, as the work flow point to Supply he/she should prove the issue and the issue will come up, otherwise the issue will be ignored. However, this problem is solving in practice like that one either the rows or columns are responsible for setting the issues but they have to talk to each other before raising an issue in the board. Another solution is that both rows and columns can raise an issue; but, it is usually an issuer who raises an issue as it is in the Volvo Pulse. However, both evaluators claim that it is not valuable to add workflow to the Pulse application.
6.1.2 Graphical User Interface (GUI)

Based on the rules and goals beyond the EPB and its complexity; it may need to have an interface towards some other application like for example Protos. Protos is like product issue management system but only related to testing. Protos report can be attached as detail report to the deviation. There are product related problems, manufacturing problems as well as process related problem in a project. Hence, EPB may need to have interface toward some other useful application.

Protos issue management system can be used in conjunction with the Pulse application. If the status of reported issues in the Protos becomes red or yellow then they will automatically show off on the Pulse board. But, in this way synchronization that is needed before raising an issue on the board is lost.

6.1.4 Advantages and Disadvantages of EPB

Both evaluators express that synchronize the data and makes sure that you have the same view in one or different places are a big benefit of EPB. On the other hand one benefit of Pulse board is that it is always available if you are co-located.

One very useful advantages of implemented web-based application is that it has the ability to be backed up. Therefore, if something unexpected happen, the information can be restored. In contrast if something unexpected happen to PPP, it might be a problem as rearranging the magnets on the board is difficult.

One of the evaluator expresses that one of the great possibilities of EPB is accessing to the system through the computer. In this way if someone gets the report regarding a problem/issue
through the email; that person can update the board easily by just coping and pasting the information.

It was claimed by one of the evaluator that throughout the Pulse meeting, just deviations will be discussed; thereupon, various windows in EPB might be extra and some unnecessary windows on the application might need to be ignored.

6.2 Summaries and Conclusion

Physical Pulse board is simple and provides good overview but, the awareness that creates with the Pulse board is the main advantage of using it. It is also easy to understand the structure of Pulse meeting and tool. Without physical Pulse board, a lot of time will be spent to discuss who are involved in each specific project whether that particular project is going well or not, but with using the Pulse board, a lot of time will be saved.

As key issues of applying physical Pulse boards in multi-project companies with physically separated development and/or cross-functional teams, are concerned, this study found out that there are various pertinent issues that immensely contributed to this and need to be dealt with accordingly. This include the inability to support distributed teams, lacking histories of Pulse board meeting, locating the physical Pulse board somewhere that people are forced to spend some time to reach it thus increasing risks of moving something from the board, imposing sanctions on the use of the board thus making it impossible to write on most Pulse boards, failure of the PPB to be available, coloring problem causing difficulties for color blinds to distinguish colors easily in the physical Pulse board, having many Pulse boards in a company and synchronization of the boards makes it time consuming, language problem, and the problem to do with hiding the deviations. In agreement to the result of current study; in Lindlöf & Söderberg; Sebestyén and Söderberg studies; difficulties to track causal link between activities,
difficulties working with distributed teams and difficulties of keeping historical data found to be the major difficulties of applying Physical Pulse board [7, 16, 18].

In responding to the above mentioned shortcomings, this study found out that there are different ways to address these issues. The use of telephone conferencing was noted in Axeborn and Bjugger as commonly used by some companies to communicate with remote parties who work in different locations along with video conferencing which facilitate communication in cross functional teams [8]. In this respect, video conferencing brings people at different sites together by concurrent two-way audio and video transmission. Additionally, excel sheet is used by some companies to handle meeting between distributed teams. In this case, before the meeting someone who is responsible of updating the excel sheet, checks the Pulse board and update excel sheet. Remote parties have access to the excel sheet so that to track the statuses of Pulse board. During the Pulse meeting, remote parties attend the meeting via telephone conferencing, video conferencing, etc. and when a change happens at the physical board the responsible person of excel sheet update it simultaneously. Video cameras were also found to be widely applied for enhancing coordination in global environment. This is where Video cameras are set in a physical Pulse board room such that during the meeting, it looks at the board and registering everything on the board and displaying them in other sites. Using EPB is the best solution to enhance coordination and synchronization between different parties (it was highlighted by the experts who involved in workshop). In response to the question of inability to store history, taking photos of Pulse board timely and have them stored digitally was mentioned as a common way that is used to store history of Pulse board. For coordination purposes, the use of the electronic board with the data base behind was highlighted as a way to improving coordination, as well as a way to store the history in some degree of quality. As the issue of limited space on the physical
Pulse board pertains, this study found out that there lacks good solution for limited space on the board. Thus, as a solution, responsible persons have to take notes during each Pulse meeting so that there is no need to write everything on the board, but if more space is needed on the board then bigger room and board should used. Moreover there is no restriction on data base system to link to other kinds of documents; in a consequence, it is possible to connect deviations to reports. In solving the problem of the availability problem, it was noted that the PPB is not available anytime and even when it is available, understanding what have happened during the Pulse meeting is rather difficult. Thus, responsible persons need to be taking notes during the PPB meeting in order to provide room for reviewing in case they forget anything or need to review something. Even so, they can take advantages of photos or excel sheet that are available for them. But if PPB meeting is missed by someone in a case of sickness or other unavailability problem, he/she could look at the excel sheets or photos if available, if not call someone and ask him for further information. By and large data base system should be employed instead of photos or excel sheet to enhance many issues including availability problem. There is a possibility within data base system to see what has changed during the meeting and if the changes related to you or affect the product line of which you are responsible for. The use of Electronic Pulse board with the data base system behind was noted as being appropriate solution to eliminate this issue. It solves this issue to some extent because everything related to Pulse board is not documented; hence attending the meeting is the big part of the Pulse board. In resolving the issue of difficulty in distinguishing different colors, symbols can be used in physical Pulse board or electronic pulse board as well. In a consequence color blind can distinguish different colors not by different colors but by various symbols. For those affected by the different board synchronization, the study highlighted that synchronization of different board is done manually by someone who is
responsible to update different boards according to specific rules of organizations. Thus, it was possible to electronically manage board synchronization by linking or mapping between boards.

Visualization is a technique used in LPD in order to improve knowledge transfer and communication. Alfredsson & Söderberg claims that images can more easily process than text [17]. Therefore, it is easier for people to communicate visually in place of just communication in written text e.g. excel sheet. The area of visualization is wide and can be done in various ways. The area that this thesis was covered was visualization according to LPD i.e. Pulse board. Two important factors in LPD are transparency and communication when decreasing unnecessary activities [22].

In general, VP, as well as Pulse Board is an effective way to easily plan activities or discuss issues on the wall without using for instance an IT-system. But the need for IT-system arises when people from different places need to participate in the meeting. Electronic Pulse board that automatically maps the Pulse board by one way around the other in different locations can be used in order to enhance the coordination between different parties. It is possible to electronically manage board synchronization by linking or mapping between boards. In this way when something has changed in a specific board, other related boards will be updated automatically according to rules. Electronic board with data base behind it can be also used not only to improve coordination but also to store the history in to some degree of quality. Furthermore, proper collection, generation, distribution, storage, disposition and retrieval of information are essential part of processes when comes to communication [54]. To do this web-base technology could facilitate communication flow e.g. through using a web-base application. Therefore, this study found out that not only restriction of using PPB can be eliminated but also
leaness of product development teams in global multi-project environment can be improved by introducing a software solution.

6.3 Future work

Future work will focus on the deeper evaluation of EPB in global environment. This means the EBP will be evaluated with expert users in distributed environment. Afterwards, further implementation may be considered.

Besides, connecting pulse board to visual planning and checklist can be done to omit some manual interconnection in between and make the work more automatic. With checklist tasks can be define and connect to Pulse board so that if a task is not performed according to its process then red or yellow deviation automatically flag. Therefore there is no need to go to the Pulse board and make the red/yellow deviation as it is already done automatically. It can also be connected to the outlook calendar or Microsoft Project therefore when a task or process is starting or finishing not according to calendar then it flag red or yellow deviation.
6.4 References


Appendices

Appendix A

1. What is your role in the Pulse board meetings?
2. How many years of experience do you have in working with Pulse board?
3. Why Pulse board is used to manage the progress of work?
4. How often Pulse board meetings are held?
5. Who participate in Pulse board meetings?
6. What are the advantages of using Pulse board?
7. What are the weaknesses of using Pulse board?
8. What are the major technical skills needed to work with Pulse board?
9. Have you ever had difficulties working with Pulse board?
10. What strategies do you use to tackle the mentioned issues?
11. How physically separated development teams participate in Pulse board meetings?
12. What are the difficulties of using Pulse board in global environment?
13. How do you tackle these difficulties?
14. Anything else you would like to add?
### Meeting: between project managers and line managers

**Purpose:**

*Planning and status*

<table>
<thead>
<tr>
<th>Business entity: Line resources (people, equipment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource A</td>
</tr>
</tbody>
</table>

| Project X | | |
| Project Y | | |
| Project Z | | |

- Project doesn’t use this resource
- Project has problem with this resource
- Project has problem with this resource (and solution is under way)
- Project has no problem with this resource
Meeting: between product managers and project managers

Purpose:
Status

Business entity: projects

<table>
<thead>
<tr>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Z</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- Product is not involved in this project
- There are problems with this product in this project
- There is/are problem(s) with this product in this project (and solution(s) is/are under way)
- Product is in this project and there are no problems
**Meeting: between product managers and lifecycle phase representatives**

**Purpose:**

**Status**

<table>
<thead>
<tr>
<th>Business entity: product lifecycle phases (planning, development, manufacturing, sales, usage, end-of-life)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product X</td>
</tr>
<tr>
<td>Product Y</td>
</tr>
<tr>
<td>Product Z</td>
</tr>
</tbody>
</table>

- **Product is not in this lifecycle phase**
- **Product has problems in this lifecycle phase**
- **There is/are problem(s) with this product in this lifecycle phase (and solution(s) is/are under way)**
- **Product is in this lifecycle phase and there are no problems**
**Meeting:** between project managers and high level management or project line management

**Purpose:** Planning and Status

Business entity: Project phases/gates (planning, pre-study, concept, detail development, industrialization, end)

<table>
<thead>
<tr>
<th>Phase A</th>
<th>Phase B</th>
<th>Phase C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Z</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Business entity: Projects

- **Project is not in this phase**
- **Project is in this phase and has problem**
- **Project is in this phase, has a problem (and solution is under way)**
- **Project is in this phase, has no problem**
Meeting: group meeting for individual planning

Purpose:
Planning and Status

<table>
<thead>
<tr>
<th>Business entity: Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project A</td>
</tr>
</tbody>
</table>

Person X

Person Y

Person Z

Business entity: persons

- Person is not working with this project
- Person is working with this project and has a problem
- Person is working with this project and has a problem (and solution is under way)
- Person is working with this project and has no problem
Meeting: between group manager and product manager or group meeting for overview of person involvement with the different products

Business entity: Product

<table>
<thead>
<tr>
<th>Person</th>
<th>Product A</th>
<th>Product B</th>
<th>Product C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Person Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Person Z</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Person is not working with this product
- Person is working with this product and has a problem
- Person is working with this product and has a problem (and solution is under way)
- Person is working with this product and has no problem
Appendix C

How the mentioned issues can be resolved with the help of the web-based application?

- Inability to support distributed teams
- Inability to store history
- Accidentally wipe the physical Pulse board
- Limited space on the physical Pulse board
- Availability problem
- Difficulty for color blind to distinguish different colors
- Language problem
- Different board synchronization
- Hiding the deviations

Anything else you would like to add?
Appendix D – User Stories

US1. As a manager, I want to be able to see in which organizational line deviation exists.
Analysis:
• Different colors can be applied to indicate different types of deviations.
• Green button means everything is according to plan.
• Yellow button means there is a problem and we know how to solve it.
• Red button means there is a problem and we do not know how to solve it.
Comments:
• Blank field means that the product line is not in the organizational line.
• Special shapes for each type of deviation are used so that it allows color blind people to distinguish the color easily.

US2. As a manager, I want to have short description (summary) of each deviation.
Analysis:
• It will be implemented in a way that clearly shows to which button it is related.
• The descriptions will be removed from screen but their history will be kept in the system after the problems have been solved [related to US7].

US3. As a manager, if there are deviations, I want to be able to have the detected deviations dates and estimated dates for resolving them to make corrective decisions accordingly.
Analysis:
• The detected deviation dates and resolving estimated dates will be removed from screen but their history will be kept in the system after the problems have been solved [related to US7].

US4. As a manager, I want to see the approaches to tackle detected deviations.
Note:
• Is it possible to use one approach to solve various deviations?
US5. As a manager, if there are reports for deviations, I want to see them to have better understanding of issues.

Analysis:

- There will be a link to Wiki page or http address to write reports.
- The reports will be removed from screen but their history will be kept in the system after the problems have been solved [related to US7].
- It will be implemented in a way that clearly shows to which deviation it is related.

Note:

- Do you need to store history? If so dedicated database is needed.
- Word and PDF documents can be attached to have more detailed information.
- Can reports be changed after submission?
- What is the size limitation of reports that need to be attached?

US6. As a manager, I want the amount of information that is shown on the screen be adjusted in a readable way.

Analysis:

- The default screen is a 42 inch touch screen LG M4214TCBA 42" WIDE TFT MULTI-TOUCH BLACK.
- The application should be always in full screen.

US7. As a manager, I want the system to store history, so that the information can be tracked.

Note:

- Who changed and when?
- Which information should be kept?
- Storing history may be done in the back end.
- Is it possible to use query to get specific information?
US8. As a manager, I want the system to have different authentication levels.

Analysis:
- For actual changes, the system will be available just during the meeting.
- Completing authentication will be done later.

US9. As a manager, I want to have the possibility to mark upcoming changes.

Analysis:
- It should be possible to mark upcoming changes even when the system is not available between meetings.

Note:
- ‘M’ sign will be shown on green, yellow or red buttons to indicate that they are marks.

US10. As a manager, the system should have the capability of defining the responsible person to confer the responsibility of each product line.

Analysis:
- The responsible person can be changed.

US11. As a manager, I want to see how many deviations in each organizational line exist.

Analysis:
- There will be just one red button for more than one deviation in each organizational line.
- There will be just one yellow button for more than one deviation in each organizational line.
- There is a possibility to have red and yellow button at the same time in each field.
- It is not possible to have yellow or red buttons at the same time with green button.
- The number of deviations will be shown on the buttons (Red or Yellow button).

US12. As a manager, I want to be able to see the deviations when the buttons are clicked.
Analysis:

- Related deviation(s) will be shown when a button is clicked on the pop up window.

US13. As a manager, I want to be able to add deviations.
Analysis:

- In order to add a deviation, the following information should be inserted:
  - Description of deviation
  - Summary of deviation
  - Corresponding product line
  - Corresponding organizational line
  - Type of deviation
  - The person who created the deviation
  - Date of creation
- When a deviation is added, its corresponding button will be shown on the screen (either red or yellow).

US14. As a manager, I want to be able to delete deviations.
Analysis:

- The deviation will be closed but its history will be kept in the system.

Note:

- What if a deviation is defined wrongly? Is this deviation changed to green or we need to delete it completely? Another way is to define another option like “ignore” in addition to red, yellow and green to indicate this deviation shouldn’t be considered in our calculation.

US15. As a manager, I want to be able to change deviations
Analysis:

- Deviation description, estimated and resolving dates, approaches to tackle deviations and reports must be removed automatically from screen after the color of button has change. [Related to US2].

US16. As a manager I want to be able to add, delete or modify detected and estimated dates of resolving deviations.
Analysis:

- Estimated resolving dates can be changed as a revision but their history will be kept in the system.
• Detected dates can be changed as a revision but their history will be kept in the system.
• The detected deviation dates and resolving estimated dates will be removed from screen, but their history will be kept in the system after they have been deleted.

US17. As a manager, I want to see time stamping/history of board statuses. [Related to US7]

Analysis:
Entrances or exits of life cycle phases can be seen if needed.

US18. As a manager I want to have the ability to add, remove or edit different rows or columns.

Analysis
Product line names and responsible person names can be easily changed on the board.

US19. As developers, we want to have just the information that needed in the add form.

Analysis:
New design form needs to be used instead of Track form.

US20. As a manager I want to have the following information for each deviation:
1) Dates (detected and due)
2) Responsible person
3) Hyperlink to the related reports (icon)

US21. As a manager, I want the system to have feature of keeping comments on deviations.

US22. As developers, we want the application to automatically refresh only on things that have changed.

US23. As a manager, I want to have the ability to edit the following information for each deviation.
1) Dates (detected and due)
2) Responsible person
3) Hyperlink to the related reports (icon)
## Appendix E – Requirement Prioritization by Value

### Table 3: Requirements Prioritization by Value (Iteration 1)

<table>
<thead>
<tr>
<th>Requirement ID</th>
<th>Requirement Description</th>
<th>Dependancy</th>
<th>Stakeholder #1</th>
<th>Stakeholder #2</th>
<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Priority</th>
<th>Importance Penalty</th>
<th>IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>US1</td>
<td>Existing deviations</td>
<td>US7</td>
<td>0.19</td>
<td>0.16</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>0.12</td>
<td>0.07</td>
</tr>
<tr>
<td>US3</td>
<td>Summary of deviations</td>
<td>US7</td>
<td>0.12</td>
<td>0.14</td>
<td>0.09</td>
<td>0.10</td>
<td>0.11</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>US3</td>
<td>Detected and Resolved Deviation date</td>
<td>US7</td>
<td>0.08</td>
<td>0.07</td>
<td>0.06</td>
<td>0.08</td>
<td>0.07</td>
<td>0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>US4</td>
<td>Approaches to tackle detected deviations</td>
<td>US7</td>
<td>0.05</td>
<td>0.06</td>
<td>0.07</td>
<td>0.08</td>
<td>0.06</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>US5</td>
<td>Link to reports</td>
<td>US7</td>
<td>0.08</td>
<td>0.09</td>
<td>0.09</td>
<td>0.08</td>
<td>0.09</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>US6</td>
<td>Readable amount of information</td>
<td>US7</td>
<td>0.18</td>
<td>0.16</td>
<td>0.18</td>
<td>0.19</td>
<td>0.18</td>
<td>0.12</td>
<td>0.07</td>
</tr>
<tr>
<td>US7</td>
<td>Store history</td>
<td>US7</td>
<td>0.09</td>
<td>0.09</td>
<td>0.10</td>
<td>0.09</td>
<td>0.09</td>
<td>0.06</td>
<td>0.04</td>
</tr>
<tr>
<td>US8</td>
<td>Authentication and access permission</td>
<td>US7</td>
<td>0.06</td>
<td>0.08</td>
<td>0.05</td>
<td>0.08</td>
<td>0.08</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td>US9</td>
<td>Mark upcoming changes</td>
<td>US7</td>
<td>0.07</td>
<td>0.08</td>
<td>0.05</td>
<td>0.07</td>
<td>0.08</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>US10</td>
<td>Responsible person</td>
<td>US7</td>
<td>0.08</td>
<td>0.07</td>
<td>0.05</td>
<td>0.06</td>
<td>0.06</td>
<td>0.04</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**Total:**

| 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.44 | 0.85 |

### Table 4: Requirements Prioritization by Value (Iteration 2)

<table>
<thead>
<tr>
<th>Requirement ID</th>
<th>Requirement Description</th>
<th>Dependancy</th>
<th>Stakeholder #1</th>
<th>Stakeholder #2</th>
<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Priority</th>
<th>Importance Penalty</th>
<th>IP</th>
</tr>
</thead>
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<td>Summary of deviations</td>
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<td>0.16</td>
<td>0.19</td>
<td>0.18</td>
<td>0.17</td>
<td>0.18</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td>US3</td>
<td>Detected and Resolved Deviation date</td>
<td>US7</td>
<td>0.14</td>
<td>0.14</td>
<td>0.17</td>
<td>0.19</td>
<td>0.16</td>
<td>0.11</td>
<td>0.07</td>
</tr>
<tr>
<td>US4</td>
<td>Approaches to tackle detected deviations</td>
<td>US7</td>
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<td>0.07</td>
<td>0.06</td>
<td>0.08</td>
<td>0.07</td>
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</tr>
<tr>
<td>US5</td>
<td>Link to reports</td>
<td>US7</td>
<td>0.11</td>
<td>0.09</td>
<td>0.07</td>
<td>0.07</td>
<td>0.08</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>US7</td>
<td>Store history</td>
<td>US7</td>
<td>0.08</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
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<td>0.04</td>
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<tr>
<td>US8</td>
<td>Authentication and access permission</td>
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<td>0.07</td>
<td>0.06</td>
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<td>0.07</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>US9</td>
<td>Mark upcoming changes</td>
<td>US7</td>
<td>0.09</td>
<td>0.09</td>
<td>0.07</td>
<td>0.09</td>
<td>0.09</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>US10</td>
<td>Responsible person</td>
<td>US7</td>
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<td>0.09</td>
<td>0.07</td>
<td>0.08</td>
<td>0.05</td>
<td>0.06</td>
</tr>
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<td>Numbers of deviations</td>
<td>US7</td>
<td>0.08</td>
<td>0.08</td>
<td>0.09</td>
<td>0.07</td>
<td>0.08</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
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<td>Deviations and related buttons</td>
<td>US7</td>
<td>0.12</td>
<td>0.11</td>
<td>0.10</td>
<td>0.09</td>
<td>0.10</td>
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</tr>
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**Total:**

| 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.45 | 0.81 |
### Table 5: Requirements Prioritization by Value (Iteration 3)

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<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Priority</th>
<th>Importance</th>
<th>Penalty</th>
<th>IP</th>
</tr>
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<td>0.05</td>
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<td>0.05</td>
<td>0.06</td>
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<td>Authentication and access permission</td>
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<td>0.08</td>
<td>0.07</td>
<td>0.07</td>
<td>0.05</td>
<td>0.07</td>
<td>0.07</td>
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<td>0.06</td>
<td>0.04</td>
<td>0.07</td>
</tr>
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<td>0.08</td>
<td>0.09</td>
<td>0.08</td>
<td>0.08</td>
<td>0.06</td>
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<td>0.08</td>
</tr>
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<td>0.08</td>
<td>0.09</td>
<td>0.07</td>
<td>0.08</td>
<td>0.05</td>
<td>0.01</td>
<td>0.08</td>
</tr>
<tr>
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<td>Deviations and related buttons</td>
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<td>0.06</td>
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<td>0.08</td>
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<tr>
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<td>0.08</td>
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<td>0.09</td>
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**Total:** 1.00 1.00 1.00 1.00 1.00 0.70 0.42 0.81

### Table 6: Requirements Prioritization by Value (Iteration 4)

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<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Priority</th>
<th>Importance</th>
<th>Penalty</th>
<th>IP</th>
</tr>
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<td>0.06</td>
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<td>0.07</td>
<td>0.05</td>
<td>0.07</td>
<td>0.08</td>
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<td>0.10</td>
<td>0.07</td>
<td>0.08</td>
<td>0.10</td>
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<tr>
<td>US8</td>
<td>Authentication and access permission</td>
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<td>0.06</td>
<td>0.08</td>
<td>0.07</td>
<td>0.07</td>
<td>0.05</td>
<td>0.07</td>
<td>0.07</td>
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<tr>
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<td>Mark upcoming changes</td>
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<td>0.07</td>
<td>0.09</td>
<td>0.09</td>
<td>0.06</td>
<td>0.05</td>
<td>0.06</td>
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<tr>
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<td>0.08</td>
<td>0.09</td>
<td>0.08</td>
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<td>0.06</td>
<td>0.05</td>
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<tr>
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<td>0.12</td>
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<td>0.06</td>
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<tr>
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<tr>
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<td>0.05</td>
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<tr>
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<td>Add, delete or modify detected and estimated of resolving deviations</td>
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**Total:** 1.00 1.00 1.00 1.00 1.00 0.70 0.44 0.85
Table 7: Requirements Prioritization by Value (Iteration 5)

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<th>Stakeholder #2</th>
<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Priority</th>
<th>Importance</th>
<th>Penalty</th>
<th>IP</th>
</tr>
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<tbody>
<tr>
<td>US4</td>
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<td>0.3</td>
<td>0.2</td>
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<td>0.05</td>
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<td>0.08</td>
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<td>0.08</td>
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<td>0.05</td>
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<tr>
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<td>0.09</td>
<td>0.09</td>
<td>0.05</td>
<td>0.06</td>
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<tr>
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<td>0.06</td>
</tr>
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<td>0.01</td>
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<td>0.05</td>
<td>0.06</td>
<td>0.06</td>
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Table 8: Requirements Prioritization by Value (Iteration 6)

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<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Priority</th>
<th>Importance</th>
<th>Penalty</th>
<th>IP</th>
</tr>
</thead>
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<td>0.06</td>
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<td>0.09</td>
<td>0.06</td>
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<td>0.05</td>
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<td>0.08</td>
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<td>0.07</td>
<td>0.07</td>
<td>0.05</td>
<td>0.04</td>
<td>0.06</td>
</tr>
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<td>0.07</td>
<td>0.05</td>
<td>0.02</td>
<td>0.05</td>
</tr>
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<td>0.07</td>
<td>0.07</td>
<td>0.05</td>
<td>0.01</td>
<td>0.05</td>
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<td>0.08</td>
<td>0.05</td>
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<td>0.07</td>
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<td>0.07</td>
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Table 9: Requirements Prioritization by Value (Iteration 7)
Appendix F - Requirement Prioritization by Value on Ratio Scale

Figure 16: Prioritized Requirements by Value on a Ratio Scale (Iteration 1)
Figure 17: Prioritized Requirements by Value on a Ratio Scale (Iteration 2)
Figure 18: Prioritized Requirements by Value on a Ratio Scale (Iteration 3)
Figure 19: Prioritized Requirements by Value on a Ratio Scale (Iteration 4)
Figure 20: Prioritized Requirements by Value on a Ratio Scale (Iteration 5)
Figure 21: Prioritized Requirements by Value on a Ratio Scale (Iteration 6)
Figure 22: Prioritized Requirements by Value on a Ratio Scale (Iteration 7)
Appendix G – Requirement Prioritization for Cost

<table>
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<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Cost</th>
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</tr>
<tr>
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<td>0.10</td>
<td>0.09</td>
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<tr>
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<td>Link to reports</td>
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<td>0.16</td>
<td>0.15</td>
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<td>Authentication and access permission</td>
<td>US7</td>
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<td>0.15</td>
<td>0.15</td>
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</tr>
<tr>
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<td>Mark upcoming changes</td>
<td>US7</td>
<td>0.14</td>
<td>0.12</td>
<td>0.13</td>
<td>0.14</td>
<td>0.13</td>
</tr>
<tr>
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<td>Responsible person</td>
<td>US7</td>
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</table>

**Table 10: Prioritization Table for Cost (Iteration 1)**

<table>
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<th>Requirement ID</th>
<th>Requirement Description</th>
<th>Dependency</th>
<th>Stakeholder #1</th>
<th>Stakeholder #2</th>
<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Cost</th>
</tr>
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<tbody>
<tr>
<td>US2</td>
<td>Summarization of deviations</td>
<td>US7</td>
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<td>US7</td>
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<td>0.08</td>
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<td>US7</td>
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<td>Store history</td>
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<td>Authentication and access permission</td>
<td>US7</td>
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<td>US7</td>
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<td>Deviations and related buttons</td>
<td>US7</td>
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**Table 11: Prioritization Table for Cost (Iteration 2)**

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<th>Stakeholder #1</th>
<th>Stakeholder #2</th>
<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Cost</th>
</tr>
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<td>US5</td>
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<td>0.09</td>
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<td>Store history</td>
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<td>0.12</td>
<td>0.14</td>
</tr>
<tr>
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<td>Authentication and access permission</td>
<td>US7</td>
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<td>0.15</td>
<td>0.16</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>US9</td>
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<td>US7</td>
<td>0.14</td>
<td>0.12</td>
<td>0.13</td>
<td>0.14</td>
<td>0.13</td>
</tr>
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<td>Responsible person</td>
<td>US7</td>
<td>0.07</td>
<td>0.07</td>
<td>0.08</td>
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**Table 12: Prioritization Table for Cost (Iteration 3)**
### Table 13: Prioritization Table for Cost (Iteration 4)

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<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Cost</th>
</tr>
</thead>
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<tr>
<td>U34</td>
<td>Approaches to tackle detected deviations</td>
<td></td>
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<td>0.08</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
</tr>
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<td>Link to reports</td>
<td>U57</td>
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<td>0.09</td>
<td>0.09</td>
</tr>
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<td>Authorization and access permission</td>
<td>U57</td>
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<td>0.15</td>
<td>0.16</td>
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</tr>
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<td>Mark upcoming changes</td>
<td>U57</td>
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<td>0.13</td>
<td>0.14</td>
<td>0.14</td>
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<td>0.07</td>
<td>0.07</td>
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</tr>
<tr>
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<td>0.10</td>
</tr>
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**Total:** 1.00 1.00 1.00 1.00 1.00

### Table 14: Prioritization Table for Cost (Iteration 5)

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<th>Requirement Description</th>
<th>Dependancy</th>
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<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
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<td>U34</td>
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<td>0.08</td>
<td>0.09</td>
<td>0.10</td>
<td>0.09</td>
</tr>
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<td>0.09</td>
</tr>
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<td>0.16</td>
<td>0.15</td>
<td>0.15</td>
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<td>U57</td>
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<td>0.12</td>
<td>0.13</td>
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<td>0.07</td>
</tr>
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<td>0.07</td>
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<td>0.07</td>
</tr>
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<td>Delete Deviations</td>
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<td>0.10</td>
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</tr>
<tr>
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<td>0.12</td>
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</tr>
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<td>0.02</td>
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<tr>
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</tr>
<tr>
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<td>Edit deviation profiles</td>
<td>U57, U510, U516</td>
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**Total:** 1.00 1.00 1.00 1.00 1.00

### Table 15: Prioritization Table for Cost (Iteration 6)

<table>
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<th>Requirement Description</th>
<th>Dependancy</th>
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<th>Stakeholder #3</th>
<th>Project Manager</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
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<td>0.08</td>
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</tr>
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<td>0.15</td>
</tr>
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</tr>
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**Total:** 1.00 1.00 1.00 1.00 1.00
Table 16: Prioritization Table for Cost (Iteration 7)

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<th>Stakeholder #4</th>
<th>Project Manager</th>
<th>Cost</th>
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<td>U323</td>
<td>Edit deviation profile</td>
<td>U37, U310, U316</td>
<td>0.05</td>
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<td>0.06</td>
<td>0.07</td>
<td>0.06</td>
<td></td>
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</tbody>
</table>

| Total          |                                                | 0.12       | 0.10           | 0.12           | 0.12           | 0.12           | 0.12            |       |
Appendix H - Requirement Prioritization for Cost on Ratio Scale

Figure 23: Requirements Prioritization for Cost on a Ratio Scale (Iteration 1)

Figure 24: Requirements Prioritization for Cost on a Ratio Scale (Iteration 2)

Figure 25: Requirements Prioritization for Cost on a Ratio Scale (Iteration 3)
Figure 26: Requirements Prioritization for Cost on a Ratio Scale (Iteration 4)

Figure 27: Requirements Prioritization for Cost on a Ratio Scale (Iteration 5)

Figure 28: Requirements Prioritization for Cost on a Ratio Scale (Iteration 6)
Figure 29: Requirements Prioritization for Cost on a Ratio Scale (Iteration 7)
## Appendix I – Cost vs. Value Comparison

<table>
<thead>
<tr>
<th>Requirement ID</th>
<th>Requirement Description</th>
<th>Dependency</th>
<th>Value</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
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<td>US1</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>Summary of deviations</td>
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<td>8%</td>
</tr>
<tr>
<td>US5</td>
<td>Link to reports</td>
<td>US7</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td>US7</td>
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<td>14%</td>
</tr>
<tr>
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<td>Detected and Resolved Deviation date</td>
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</tr>
<tr>
<td>US9</td>
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<td></td>
<td>6%</td>
<td>15%</td>
</tr>
<tr>
<td>US8</td>
<td>Authentication and access permission</td>
<td></td>
<td>6%</td>
<td>13%</td>
</tr>
<tr>
<td>US10</td>
<td>Responsible person</td>
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<td>7%</td>
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</table>

Table 17: Comparing the Cost and obtained Value for each requirement (Iteration 1)

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<th>Dependency</th>
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<th>Cost</th>
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</thead>
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<td>Link to reports</td>
<td>US7</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
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<td>Deviations and related buttons</td>
<td>US7</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td>US7</td>
<td>Store history</td>
<td></td>
<td>7%</td>
<td>14%</td>
</tr>
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<td>US10</td>
<td>Responsible person</td>
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<td>6%</td>
<td>7%</td>
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<td>Numbers of deviations</td>
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Table 18: Comparing the Cost and obtained Value for each requirement (Iteration 2)
### Table 19: Comparing the Cost and obtained Value for each requirement (Iteration 3)

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<tr>
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<td>Deviations and related buttons</td>
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<td>9%</td>
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<td>9%</td>
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<td>US9</td>
<td>Mark upcoming changes</td>
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<td>13%</td>
</tr>
<tr>
<td>US8</td>
<td>Authentication and access permission</td>
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<td>7%</td>
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<tr>
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### Table 20: Comparing the Cost and obtained Value for each requirement (Iteration 4)

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<td>US11</td>
<td>Numbers of deviations</td>
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<td>15%</td>
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<td>US9</td>
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<td>13%</td>
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<td>14%</td>
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<td>8%</td>
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<td>7%</td>
<td>13%</td>
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<td></td>
<td>7%</td>
<td>15%</td>
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<tr>
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<td>US15</td>
<td>Change deviations</td>
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<td>6%</td>
<td>11%</td>
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Table 21: Comparing the Cost and obtained Value for each requirement (Iteration 5)

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<td>9%</td>
<td>4%</td>
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<tr>
<td>US23</td>
<td>Edit deviation profile</td>
<td>US7, US10, US16</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>US10</td>
<td>Responsible person</td>
<td></td>
<td>8%</td>
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</tr>
<tr>
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<td>7%</td>
<td>4%</td>
</tr>
<tr>
<td>US4</td>
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<td></td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>US8</td>
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<tr>
<td>US17</td>
<td>Time stamping/history of board statuses</td>
<td>US7</td>
<td>5%</td>
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<tr>
<td>US18</td>
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Table 22: Comparing the Cost and obtained Value for each requirement (Iteration 6)
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<th>Value</th>
<th>Cost</th>
</tr>
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<tbody>
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<td>US23</td>
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<td>14%</td>
<td>6%</td>
</tr>
<tr>
<td>US22</td>
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</tr>
<tr>
<td>US15</td>
<td>Change deviations</td>
<td>US2</td>
<td>8%</td>
<td>11%</td>
</tr>
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<td>US9</td>
<td>Mark upcoming changes</td>
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<td>8%</td>
<td>13%</td>
</tr>
<tr>
<td>US4</td>
<td>Approaches to tackle detected deviations</td>
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<td>7%</td>
<td>9%</td>
</tr>
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<td>US16</td>
<td>Add, delete or modify detected and estimated of resolving deviations</td>
<td></td>
<td>7%</td>
<td>12%</td>
</tr>
<tr>
<td>US8</td>
<td>Authentication and access permission</td>
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<td>15%</td>
</tr>
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<td>US10</td>
<td>Responsible person</td>
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<td>6%</td>
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<tr>
<td>US17</td>
<td>Time stamping/history of board statuses</td>
<td>US7</td>
<td>6%</td>
<td>9%</td>
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<tr>
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<td>Improvement of add forms</td>
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Table 23: Comparing the Cost and obtained Value for each requirement (Iteration 7)