IMPLEMENTATION MODEL TO AN ANDON SYSTEM FOR VEHICLE MANUFACTURER

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Abstract

Purpose – The purpose of this thesis is to develop an implementation model to an Andon system, which makes the implementation efficient and effective on a vehicle manufacturing assembly line. In order to conduct this, the purpose was broken down to three research questions.

1. How can the Andon system at an assembly line be designed?

2. What are the contemporary models for implementing systems?

3. How can an efficient and effective implementation model for an Andon system be designed?

Method – To find an answer to the first research question four case studies with interviews and observations have been made. A literature study was also conducted in order to understand the subject. The following question was answered from literature studies and collected empirical data.

Findings – Through case studies, empirical qualitative data about the Andon implementation were collected. This was later analysed by the authors by dividing the collected data into three parts. The first part is about how an Andon system can be designed using different layouts and how to decide a particular layout considering the different possibilities. The second part is how the implementation model PDCA can be used as a base of the implementation project for the implementation team. Finally, the last part describes the whole model and how to start and finish it.

Limitations – The case companies that were chosen are only those who already have done the Andon implementation on their assembly line. In order to see alternative solutions to otherwise similar problems, authors have chosen to study vehicle manufacturers as well as manufacturers outside of the vehicles branch. Only the implementations phase is in focus to investigate. Further more the thesis will however not include any economic aspects or any aspects regarding software.

Further Research – During the study of research question one, six different layout features were highlighted. From the authors’ knowledge, these six layout features are the most essential features to consider designing an Andon system. However, it is important to state that this study do not mention all of the affecting features to design an Andon system. Further research on other features in an Andon System is therefore recommended. Secondly, as the authors are relying on the interviewed person’s feedback of the differences in the output of an Andon system, the authors recommend self- observations in order to raise the validation of the result.

Keywords- Andon System, Implementation model, Vehicle assembly line, PDCA
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1 Introduction

This chapter introduces the background and problem formulation before presenting the thesis purpose. The purpose is then followed by questions of issue. The chapter is then narrowed down with scope and delimitations followed by disposition.

1.1 Background

Globalization is accelerating due to the rapidly increasing economic interdependence of countries (Ricupero, 1998). According to past literature the two most frequently mentioned effects from globalization are; global market opportunities and global market threats (Fawcett, Calantone & Smith, 1997; Closs & Fawcett, 1993; Taieb, 2002; Jones, 2002). The global market threats can be further categorized into global competitive threats which can be defined as increased competition in global markets. Global competitive threats are created from larger numbers of competitors in the global marketplace (Taieb, 2002; D’Aveni, 1994). Although globalization contributes to firm’s market opportunities, it also increases the amount of competition as firms operating on domestic, regional, international and global level are now competing against each other (Keats, DeMari, & Hitt, 1998; Harvey & Novicevic, 2002).

Globalization has also contributed to higher customer awareness as it enables customers to gather information easier, faster, and at lower costs. The awareness of alternative products makes it easier for the customer to switch products (Castrogiovanni, 1991). According to different studies (Bishop, 1984; Doyle, 1984; Olson & Jacob, 1985; Sawyer & Dickson, 1984; Schechter, 1984), consumers chooses the product based on three different pivotal determinants; price, quality and value. Because a firm should always strive to create more value for the customer (Thomke & Von Hippel, 2002), a firm should focus to continuously improve these three determinants.

One way to improve all the three determinants is by decreasing product defects in the manufacturing process (Nicholas, 1998). According to Raturi and Evans (2005), by eliminating product defects companies can assure a better quality as this increases the chances of a satisfied customer. Raturi and Evans (2005), explains the possibilities of lower production cost which in its turn could create lower selling prices to the customer by decreasing product defects in the manufacturing process. Striving to eliminate product defects in the manufacturing process, many vehicle manufacturing companies look to implement Andon system (Li & Blumenfeld, 2006). The purpose of Andon is to detect defects as they appear, find the root cause of the defect, fix the defect and to make things right the first time by stopping production as defects are detected (Li & Blumenfeld, 2006). According to Monden (1994), this is the most effective and cost saving techniques to handle product defects in the manufacturing process as undetected defects requires disassembly and rework which takes longer time and has a higher cost.
1.2 Problem Formulation

Management often feels frightened and lost when it comes to implementation. Managers wonder how they can get from great plans for a successful future to actions that will actually create these successes for the company (Van Buul, 2010). This often leads to companies jumping into the implementation phase without much planning, leading too much time spend on fighting fires to resolve the errors and inconsistencies (Hunt, 1993). According to (Durlak, 2011), an unsuccessful implementation can do more harm than good to a company as it can for example hurts peoples working motivation, waste funds and energy. By properly planning the implementation process and creating a clear implementation structure before the actual implementation process starts significantly increases the chances of a successful implementation (Hunt, 1993).

The careful planning and execution of implementing a manufacturing system also regards the Andon system. There are according to Everett & Sohal (1991), two patterns of behavior that can arise among the operators from a poor implementation. The first is over-utilization of the system and the second is the reverse, underutilization. Overutilization is the scenario when operators interrupts the manufacturing flow by stopping the line more frequent than is proven necessary. One possible mind set of the operator may be to just keep pressing the stop button as an excuse to stop working (Everett & Sohal, 1991). Underutilizing is the scenario when the operators ask themselves, just why they should take the trouble to tell management that a quality problem has appeared. The problem may be based on the fact that the operators have never shown any real interest in the company or its products in the past and are afraid of appearing incompetent when pressing the Andon button. It therefore seems to be more trouble than good to press the button and stop manufacturing (Everett & Sohal, 1991).

When planning a project there are many different factors influencing a decision which in its turn can change the outcome. It is therefore important to collect the right information and organize the information in a way which will help the decision maker to take the right decision (Magnusson & Olsson, 2010). A clear model would therefore be helpful to vehicle manufacturing companies which are looking into designing and implementing their own Andon system. There is today however according to research made by authors at; HJ Library¹, Google Scholar, CNKI², SUB³, LUB⁴, UMU Library⁵, UU library⁶ and various libraries in Bangkok, no model for implementing an Andon system which raises the need for this study.

¹ Jönköping University Library
² China National Knowledge Infrastructure
³ Stockholm University Library
⁴ Lund University Libraries
⁵ Umeå University Library
⁶ Uppsla University Library
1.3 Purpose
The problem description above describes the importance of a solid implementation to an Andon system. The problem description also mention how there today is no standard model on how to implement an Andon system. The consequence to a poorly implemented Andon system and process is that the Andon system never gets utilized to its full potential. The purpose of this thesis will therefore be as following:

“To develop an implementation model to an Andon system, that makes the implementation efficient and effective on a vehicle manufacturing assembly line”

To fulfill the purpose of the thesis, the thesis has been divided into three questions of issue. Because it is important to create a deep understanding of how an Andon system can be used as well as how it can be implemented before developing an implementation model, Johansson (2014), the first question of issue will be as following:

1. How can an Andon system at an assembly line be designed?

After an understanding for how an Andon system can be designed at an assembly line, the next step is to create knowledge of different implementation models used for when implementing other systems. The second question of issue has therefore been formulated as following:

2. What model for implementing systems is there today?

The answer to the first and second question of issues provides information to design an efficient and effective implementation model to an Andon system. To answer the thesis purpose the third and last question is as following:

3. How can an efficient and effective implementation model for an Andon system be designed?

1.4 Scope and delimitations
The focus on this thesis is to develop an implementation model to an Andon system. This will be done by studying different companies which has already implemented an Andon system in their manufacturing. The different companies used in the study will not only be on vehicle manufacturers but on manufacturing companies from different industries. The thesis will be limited to study the implementation process of an Andon system and any difficulties experienced by other companies. The thesis will however not include any economic aspects or any aspects regarding software.
Figure 1. Delimitations to one assembly line

As shown in figure 1 bellow an Andon system can be a part of many different processes within manufacturing, this thesis will however only be studying the Andon system and process at the assembly line. Because the case companies have more than one assembly line, this thesis has been limited to study one assembly line at each case company.
1.5 Disposition

The thesis is divided into seven different chapters. The chapters are structured in order for the reader to in the best way possible be able to understand the thesis final conclusions. Each chapter explains in depth the different major steps taken.

In the first chapter, Introduction, a background of the thesis purpose is presented, after this a description of the problem is made. This is followed by the thesis purpose which is then divided into three questions of issues. The last part in the first chapter is scope and delimitations which describes where the area of concern is. Chapter two, Methodology, describes what the different work processes are and what type of research approach has been used. The final part of chapter two is reliability and validity, this part is for motivating how the collected data and information is reliable and valid. The third chapter, Frame of reference, provide theory knowledge used in the thesis. In frame of reference the concept of Andon is describe together with different implementation models and management literature. The fourth chapter, Empirical study, presents all the empirical data which was found from studying the chosen case companies. Chapter five, Analysis, analyzes the all the collected information in a structured way by breaking down and then reassembling the data. The sixth chapter, Discussion and conclusion, firstly discusses the strengths and weaknesses of the approach used to achieve the thesis purpose and how reliable the result is and if the purpose of the thesis has been accomplished. Secondly a final conclusion of the thesis is made which is followed with recommendations what further research can be done to develop the Andon implementation model.
2 Methodology

This chapter provides the various steps adopted by the authors during the research. It describes the connection between the questions of issue and research methods, including the work process, research methods, data analysis and what the authors have done to create a valid and reliable result.

2.1 Connection between Question of Issue and Research Methods

To answer the questions of issue a literature study and a case study have been accomplished. A case study was performed in order to provide empirical findings leading to an answer for the first question of issue. To provide an answer for the second question of issue a literature study was performed. The findings from question one and two where then combined together to form an answer to question of issue three. The different methods and approaches used will be described in detail further down in this chapter. Figure 2 presents the methods used for each question of issue.

![Methodology Diagram](image)

Figure 2. Questions of issue and method connection

2.2 Work process

The thesis work has gone through five main steps. A Gant-schedule has been created bellow to show these different processes. As shown in figure 3 the thesis work started in week 5 and was finish in week 29. The work started with a pre- study. This is where the authors created a better understating of the subject content. The second process of the thesis was to dig in deeper into the more relevant material found in the pre- study. The third step was to make a plan what research approach was going to be done. The fourth process was to execute the research approach planned in the previous step. Lastly the authors analyzed the collected data in order to form answers to the questions of issue.
2.3 Research Approach

This study is based on a qualitative research approach. According to Cresswell (1994), qualitative research is an approach which involves discovery that occurs in a natural setting which enables the researchers to develop knowledge by involvement of actual experiences. A good qualitative research is created through a logical chain of reasoning, multiple sources of related evidence to support an explanation, and ruling out rival hypotheses with convincing arguments and solid data (Flick, 2013).

To answer the first and second question of issue the research approach has been of a descriptive character whereas the methodology used for the third question of issue has been of causal comparative character. Descriptive research involves identification of attributes of a particular phenomenon based on an observational basis (Williams, 2007). Causal comparative research involves for the researchers to analyze the cause and effect relationships between the variables (Vogt, 1998).

For a descriptive research method there are usually four methods used which are; correlational, developmental design, observational studies, and survey research (Williams, 2007). For the first question of issue, an interview protocol was conducted through interviews. A survey has the objective to collect data from respondents that represents a population (Williams, 2007).

2.4 Case Study

There are different types of qualitative research techniques. According to Williams (2007), there are five different areas of qualitative research, which are; case study, ethnography study, phenomenological study, grounded theory study, and content analysis. These five areas are built upon inductive reasoning rather than deductive reasoning as the researcher tries to find an answer to the opposed question from observations made (Williams, 2007).

A case study is a research strategy which focuses on creating a better understanding of a certain issue. During a case study it is common that data is collected through interviews, observations, surveys and documents (Eisenhardt, 1989). A case study is conducted in this thesis due to the limited literature of the subject. According to Yin (2007), a case study is designed from two measurements which are; number of cases and number of units to analyze.
The case study performed in this thesis focus on one unit at four different case companies. According to Marshall (1996), the reliability and validity is strengthened by using more cases as it creates a general result. When choosing companies for the case study a convenience sampling selection was used based on volunteering companies within any industry sector using an Andon system. The risk of convenience sampling selection is according to Marshall (1996) is that collected data may be of low quality which will have an effect of the reliability as it might not represent a population as a whole.

2.5 Data Collection

It is important to collect valuable data when performing empirical research. The appropriate kinds of data collection procedures and data collection for qualitative research differ depending on the empirical research. The reason for this is as the empirical research target may have different distinctive characteristics and challenges (Yin, 2011).

2.5.1 Literature study

A literature study was first conducted in the pre-study in order for the authors to get a better understanding of the thesis framework. As an understanding of the thesis framework had been created among the authors the authors then moved on to study literature of what possible research approach the authors would choose to carry out and how this research approach was going to be carried out. As a research approach had been selected the authors then focused more on studying literature more specific to the selected topic within the thesis subject.

Literature has been found from two different sources; university libraries and online search engines. The authors have studied literature from the Asian Institute of Technology Library, Bangkok University Library and from the Library of Thammasat University. To find more relevant and complimentary literature, online library search engine from; Google Scholar and Jönköping Library has also been used.

2.5.2 Interviews

Interviews can be performed in two main ways. One is a structured interview and the other is a quantitative interview (Yin 2010). All interviews have been prepared with written down questions. However, due to the semi-structured interview technique the interviewer allowed the interviewed person to go outside the question topic.

All interviews have been phone interviews. The disadvantage of this is that the interviewer is not able to see the person being interviewed. By not being able to see the interviewed person means that the interviewer loses the ability to read the body language of the interviewed person. Body language can be used by the author to for example if a question makes the interviewer uncertain which for the interviewer would mean a need to dig deeper into this field. Figure 4, presents all the interviews that have been carried out.
Methodology

<table>
<thead>
<tr>
<th>Case company</th>
<th>Purpose of interview</th>
<th>Case Company Role</th>
<th>Method</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>The process today</td>
<td>Logistics manager</td>
<td>Semi-Structured</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>What they want</td>
<td>System manager</td>
<td>Semi-Structured</td>
<td>15</td>
</tr>
<tr>
<td>1</td>
<td>Andon Survey</td>
<td>Production manager</td>
<td>Semi-Structured</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Andon survey</td>
<td>Production manager</td>
<td>Semi-Structured</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Andon survey &amp; implementation</td>
<td>Project manager</td>
<td>Semi-Structured</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Andon survey &amp; operators</td>
<td>Plant manager</td>
<td>Semi-Structured</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Andon survey</td>
<td>Project manager</td>
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<td>Andon survey</td>
<td>Production manager</td>
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Figure 4. Completed Interviews

All interviews have been recorded. This has meant that no manual recording has had to be done during the interview. This in an advantage during the interview, as both interviewers had the chance to develop further questions. A second advantage is that the exact answers to the questions asked can be played over and over again for the authors to reflect on. This has created a more valid result to the thesis as the exact answers from the interviewed person have been analyzed.
2.6 Data Analysis

According to Yin (2011), the analysis of qualitative data should move through five phases. The analysis began by compiling the collected data. Compiling the collected data was done through notes and recordings. After data have been collected was the data disassembled into separate parts. The reason for disassembling the compiled data is to create a better overview of the data in order to see a pattern (Yin, Qualitative Research from Start to Finish, 2011). A pattern in the disassembled data has been created through constant comparisons between the data. The third phase is called reassembling. Reassembling is when data is organized in different categories. LeCompte (2000) explain this step as building and reassembling puzzle pieces, by for example; by placing all the pieces belonging to the sky near the top. In this thesis the data has been placed into an SWOT analysis. As a pattern had been discovered the data then got reassembled according to the discovered pattern. (Yin, Qualitative Research from Start to Finish, 2011).

Figur[...]

Figure 5. Representing the five phases & and the methods used

The fourth phase involves interpreting the assembled data. It is during this phase the entire puzzle is being built as analysis is brought together, creating a basis for the researcher’s entire understanding of the study (Yin, Qualitative Research from Start to Finish, 2011). Beyond the interpreting phase lies the fifth analytic phase, concluding. This is a series of statements which races the findings of the study to a broader set of ideas (Yin, Qualitative Research from Start to Finish, 2011).
2.7 Reliability and Validity

A valid study is when data is properly collected, so that the conclusions accurately reflect and represent the real world that was studied. False findings or assumptions form any field should be considered worthless which weakens the result reliability and validity. Even though the result may be reliable and valid, questioning the reliability and validity should always be made. Ideally, the conclusion to a problem and result given the same lens or orientation to another study would have collected the same evidence and have drawn the same conclusions (Yin, 2011).

Maxwell summarizes seven ways for addressing validity challenges; intensive long-term involvement, rich data, respondent validation, search for discrepant evidence and negative cases, triangulation, quasi-statistics and comparison. Out of these seven ways to create validity, this thesis has conducted three ways to create validity; rich data collection, respondent validation and comparison.

Rich data has been collected by several interviews with one or more people within the case company. Detailed data has been collected this way as data collected from the first interview have been reflected and new questions have come up which is then asked to an appropriate person within the case company. The second way to create data rich is to double check with other people than the first interviewed person to see if the same answer for the same question is received.

Respondent validation has been carried out as the collected and summarized data has been checked with the interviewed persons to make sure the right information is in the collected data content.

The third and last technique to create a valid result for this thesis is that a comparison between different interviewed persons within the same case company has been done. This creates more valid data as the collected data from a case company but different persons need to be the same. If the data is not the same from two different sources within the same case company the collected data should not be considered to be used until the disagreement becomes an agreement between the two sources.
3 Frame of reference

This chapter summarizes the most important and relevant theoretical frameworks included in this thesis. Initially, the theory is linked together with the purpose of the thesis, followed by in-depth information of every theoretical framework.

3.1 Andon

The word Andon means paper lantern in Japanese and is a system which provides visual feedback to the plant floor (Zidel, 2006). Typically, the Andon system indicates the line status and shows when assistance is needed. The Andon system empowers operators to stop the production process if any quality issue arises and assistance is needed (Lean Manufacturing Andon, 2015).

The Andon system is a set of Andon buttons/chords, Andon lights and one or many Andon boards installed at the assembly line (Nicholas, 1998). The Andon lights are green as long as work is proceeding normally, but are switched to yellow when a worker needs assistance and a possible delay is expected from the station. If the worker stops the assembly line a red Andon light over his station will light to indicate which process is responsible for the stoppage. The supervisor then goes immediately to the workstation to investigate the problem and take necessary corrective action in order to start the assembly line (Monden, 1994).

Lean Manufacturing refers Andon to any visual display which shows status information from the plant floor. The first Andon system in manufacturing was simple lights that enabled operators to signal line status based on colors. Today, more sophisticated visual displays are often used in the Andon system. Apart from Andon lights the Andon system today normally also include an Andon board which has the purpose of distributing other key information regarding the manufacturing status which the Andon light cannot provide (Lean Manufacturing Andon).

According to Lean Manufacturing Andon, Andon is an effective communication tool. Andon brings immediate attention to problems as they occur in the manufacturing processes, it provides information to the plant floor, encourages immediate reaction to quality defects, highlights down time, safety problems and encourages operators towards improvement by increasing their responsibility for “good” production.

3.2 Implementation models

3.2.1 PDCA

The PDCA cycle has its origin with Dr. Walter A. Shewhart which in his book from 1939 displayed the first version of the “Shewhart Cycle. In 1950, Deming modified the Shewhart cycle as he went to Japan holding seminar on statistical quality control (Moen & Norman). The Japanese called the modified model the “Deming wheel” later also called the PDCA Cycle and is a four step cycle for problem solving including. The four letters P, D, C, A, stands for Plan, Do, Check, Act, which is presented in Figure 6. The PDCA cycle continuously look for better methods of improvement and is effective when both doing a job and managing a program (Sokovic , Pavletic , & Kern Pipan, 2010).
• **Plan – Design**
This first phase have the task to investigate and analyze the current situation and fully understand the current problem and describe the current process. If several problems arises the problems needs to be prioritized, for example in a prioritizing matrix (Gorenflo & Moran, 2013). After an understanding of the problem has been created the possible causes of the problem needs to be identified together with the root cause of the problem, this can be done with the help of the 7 quality tools, cause & effect or by asking the 5 why. Next step is then to develop a plan to see an opportunity for potential improvements and to give a solution to the problem that will be tested. This is done by creating measurable goals (Gorenflo & Moran, 2013). According to Gorenflo and Moran, PDCA don’t tell how to analyze the data or situation, a separate analysis process is carried out throughout the organization. It is therefore important to document the plans in order to help analyze its effectiveness later.

• **Do – Production**
In the do-phase implementation of the action plan that had been developed at the earlier plan-phase is carried out (Gorenflo & Moran, 2013). In this phase the approaches are implemented systematically in all relevant areas and to the full extent. It is important to check that the appropriate tools for measuring the improvements after the implementation has been done exists (Gorenflo & Moran, 2013).

• **Check – Sales**
The third phase requires analyzing the effects which the implementation had. This is done by comparing data which should determine if an improvement was achieved (Gorenflo & Moran, 2013). This should be done firstly by contacting the team responsible for the project, in order to check a list of problems and solutions they have encountered. This information is then shared with the team. The purpose to this is for everyone in the team to know and understand how to avoid these problems, or to fix them if they happen to reappear again later. Mindtols article claims that: *Depending on the success of the pilot, the number of areas for improvement you have identified,*
and the scope of the whole initiative, you may decide to repeat the "Do" and "Check" phases, incorporating your additional improvements.

- **Act – Research**
  This phase uses the knowledge about the root causes and how to make a decision on fully implementing the solution. Gorenflo and Moran says that there are three options that can be chosen when implementing the solution. The first option is to standardize the improvement and to make it measurable. The second option is for the team to repeat the earlier test to gather some more data. This can be caused by chanced circumstance, error in logging data and validity of analyzing data. The third option is to abandon the solution. This can be the case if earlier test did not result in improvement of the output (Gorenflo & Moran, 2013). As this phase has been completed the user should look back to the plan phase to find further areas of improvements. (Moen & Norman)

### 3.2.2 Six Sigma
Six Sigma began as a statistically-based method to reduce variation in manufacturing processes for Motorola Inc. in the 1980s. Six Sigma is named after the statistical concept as a process should only be allowed to produce 3.4 defects per million opportunities (Raisinghani, Ette, Pierce, Cannon, & Daripaly, 2005). Six Sigma has had various definitions as it is continuously evolving. However, Motorola Inc., who first developed the methodology and who provide complete Six Sigma training and consultancy services, defines Six Sigma in 2005 as the following:

"Six Sigma has evolved over the last two decades and so has its definition. Six Sigma has literal, conceptual, and practical definitions. At Motorola University (Motorola's Six Sigma training and consultancy division), we think about Six Sigma at three different levels: As a metric, as a methodology and as a management system. Essentially, Six Sigma is all three at the same time."

The two most common used Six Sigma methodologies in Six Sigma are DMAIC and DMADV. DMAIC is short for its processes; Define, Measure, Analyze, Improve, Control whereas DMADV is short for Define, Measure, Analyze, Design, Verify. Both methods have the purpose of making a business process be more efficient and effective. DMAIC and DMADV are not identical as the methodologies were developed for use in different business processes but do however share some characteristics (Graves, 2012).
According to Graves (2012) and Selvi & Majumdar (2014) DMADV is in general associated with new services and product designs and should be used when implementing products or processes which do currently not exist. In rare occasions DMADV can also be used when an already existing process does not meet expectations or fails to make improvement. DMAIC on the other hand is used on a product or process that already exists but is in need of improvement (Graves, 2012).

3.2.2.1 **DMADV**

As earlier stated the DMADV methodology is an improvement system used to develop new processes or products and consists of five phases. As technology has advanced and made greater data collection and analysis possible, there has been increased importance on basing decisions on more data (DMADV: An Approach for Developing New Initiatives, 2008). It is important to remember that when the implementation fails using the DMADV approach the failure will affect the entire process as there will not be any alternatives to go back to. The failure using DMADV implementation methodology might therefore increase cost and delay other project processes. (Narayanasamy).
1. Define Phase
Project leaders should in this phase identify wants and needs which to the customers are the most important. Wants and needs are identified through historical information, customer feedback and other information sources (Selvi & Majumdar, 2014). After identifying the purpose of the project, realistic and measurable goals should then be defined. During this step A clear definition of the project is established, which must be aligned with the strategy and goal expectations of the company as well as with the customers needs (Graves, 2012).

2. Measure Phase
The goal of the Measure phase is to identify appropriate measurement systems that will capture the performance of CTQs (Critical to Quality) (Narayanasamy). In order to do this the first step is to convert stakeholder requirements into CTQs. The VoC collected in the Define Phase would act as an input for identifying the CTQs. The second step would then be how to measure the CTQs. The defined CTQs should be converted into metrics that can be measured and reported. The last step of the phase is then to define a measurement plan that answers to questions such as what, when, who and how (Narayanasamy).

3. Analyze Phase
After identifying the CTQs the focus should turn to design features and how they should be planned to meet the customer requirements (Narayanasamy). Actions taken during this phase will include: developing design alternatives, identifying the optimal combination of requirements to achieve value within constraints, developing conceptual designs, evaluating then selecting the best components, then developing the best possible design (Graves, 2012).
4. **Design Phase**

The Design phase is the most critical phase of DMADV, as this determines the success of the project (Narayanasamy). The results of internal tests are compared with customer wants and needs. Any additional adjustments needed are made (Selvi & Majumdar, 2014). Once this step is complete, a more detailed model will be prototyped in order to identify where errors may occur and to make necessary modifications (Graves, 2012). The improved manufacturing process is then tested and test groups of customers provide feedback before the final product or service is widely released (Selvi & Majumdar, 2014).

5. **Verify Phase**

By the end of the Design phase a design ready to be implemented should be completed. The last step before implementation should be to validate that the Design is appropriate in normal working conditions (Narayanasamy). Several pilot and production runs will be necessary to ensure that the quality is the highest possible. Here, expectations will be confirmed, deployment will be expanded and all lessons learned will be documented. The Verify step also includes a plan to transition the product or service to a routine operation and to ensure that this change is sustainable (Graves, 2012).
4 Empirical Study

This chapter presents collected empirical data. Empirical data has been collected from four different Swedish case companies. The collected data is presented through a description of each case company. The description introduces the case company, describes how the Andon system was implemented, the design of system and how the case company works with their Andon system.

4.1 Case company from the Vehicle industry 1

The factory started implementing Andon to its assembly line in 2001 and finished the implementation the following year in 2002. The motivation for implementing an Andon system was to better manage work within takt time and to create better data for where in the assembly line deviation appears.

The technical part of this implementation was relatively smooth without delay. After the technical implementation and the company started using the Andon system in the operation process a misuse of the system was quickly observed as operators used the system to get longer breaks. The reverse problem of misuse was also observed as operators chose not to press the Andon button from fear of showing the appeared problem. The company has been working to eliminate these problems ever since they were firstly observed. Today these problems no longer exist as a new mindset to the system has been created. The first step towards eliminating this problem was

The assembly line is divided into different stations. Each station is different long and has different takt time. The takt time depends on the demand and station capacity. The assembly line is automated, meaning that the line has a continuous movement. The parameters distance and speed of the assembly line can be adjusted by the line control system. Each station is equipped with an Andon chord that is pulled if the operator notices any assembly problem or thinks that the work cannot be done within takt time. When the Andon chord is pulled the line stops at the end of the takt time unless the problem have been fixed within takt time, then the operator pulls the Andon chord a second time in order to delete the stop function. As the Andon chord is pulled the first time a signal arrives at the Andon board that alarms the team leader. The team leader then walks over to the station to assist the operator with whatever problem may exist. The team leader does not record any data or any notifications of why the Andon button was pressed unless it is a reoccurring problem.

The Andon system also consists of three Andon boards. One board visualizes the goal of completed units for the shift, number produced, and any deviation from goal. At the end of the assembly line “Direct run” as a percentage is presented. Direct run means if a cab goes directly go to loading area or needs any rework. The second board presents the station statuses, just showing what position has pulled the cord. The third board presents other KPI’s for the line segment.

4.2 Case company from the Vehicle industry 2

The case company is a global manufacturer. The study has taken place at the Swedish plant. The Andon has been a part of the manufacturing process for a long time and has been developed in small steps at a time.
The Andon process begins as an operator presses the Andon button (this does not stop the assembly line). This produces an alarming signal to the Andon board and to the group leader that something is wrong at the station where the signal was send out from. The team leader then walks over to the station in need to help solve the problem. This is done for example if the station has fallen behind in the takt time, the team leader would then take over the unit the operator is currently working on in order for the operator to start with the new unit. In the same process as the team leader helps the operator the team leader also notes down data such as for example, character of problem, cause for problem and time when Andon button was pressed.

The assembly line is divided into different sections, with each section containing on average 10 working stations. In each section on average 40 operators work. In addition to these 40 operators there are 4-6 group leaders with the responsibility to function as support for the Andon system.

An Andon board is used for visualization of production status. The board presents the station statuses.

4.3 Case company from the Gardening industry

The case company manufactures gardening equipment and is one of the leading companies in the industry. The production site used consists of two separate factories that produce products form different product groups, but has newly undertaken a new structure in the factory functions. An Andon system was implemented in 2004 for one factory and in 2008 for the other factory. The reason to the implementation of Andon was as the manufacturing went from a slower flow to a high flow system in the manufacturing operations. Andon would help the operations to keep up with the high flow system by offering support where it would be needed. After the last implementation in 2008 the case company reorganized the factory functions as the two factories now work as one factory, manufacturing the same products.

During the merger of the two factories the case company observed that the Andon system form one factory had been working better compared to the Andon system in the other factory. The problem with the Andon system at the factory was that the operators had a negative attitude to the Andon system. It was observed that the operators often ignored the Andon purpose. The reason for this is believed to lay in the operator mind set, as the operators were afraid to appear indolent when asking for help. As the operators did not require help by pressing the Andon button bottlenecks appeared that disturbed the high flow system.

This problem had however not appeared in the other factory. The reason for this was because the Andon system operated differently. The Andon system worked in the same way as the Andon system in the other factory except for that this Andon system had the possibility to call for help through a “silent” signal. A silent signal calls for help when help at the stations is needed. It is an automatic signal calling for help without any action from the operator. The production system with different takt times which needs to be followed. If however the takt time at a station is not achieved the Andon system sensors that the takt time is not reached. It is when the takt time is not achieved that the Andon system calls for help through a silent signal unless the operator realizes the situation before the Andon system does.
As a station calls for help a Team leader arrives at the station to see what the problem may be and to help solve the problem. There are on average three team leaders on every floor section. There are usually 20-25 operators operating at each floor section. The team leader has the ability to delegate the responsibility of the team leader role in the Andon system. As the team leader arrives at the station recording of the problem is done on a touch screen devise. There are different reasons to why the Andon signal gets alarmed which also gets differently classified by a tick in a box. If however a quality problem appears that the Team leader more thoroughly notes down details such as cause or detailed description. Quality problems are noted down manually with the help of a classic paper and pen method. Other information such as when the signal was alarmed, how many alarms have been signaled and how long the problem existed for is recorded by the Andon system itself. This information is then analyzed. There are different people involved when analyzing the data depending on what information needs to be analyzed, for example, analyzing quality problems is done by the associated working group together with a production technician.

The case company has an Andon boards hanging high up by the sealing in order for operators to have clear vision of all the station statuses, scheduled completed units, real time completed units, difference between scheduled and real time completed units, product quality and the takt time. When a station status signals a problem on the Andon board, the station it regards is ether black with yellow text which indicates a silent alarm or is white with red text which indicates that an operator at the station has pressed the Andon button.

4.4 Case company from the Illumination industry

The illumination company was established in Sweden in 1945 and is today a multinational company with production in four different countries. The study has been taken place at the company factory in Sweden. Products produced in the Swedish factory are for example; lamp frames, care equipment and other light accessories.

The case company implemented the first Andon system in 2010 and has today covered 70 % of all the assembly lines with operating Andon systems. Their main motivation for implementing an Andon system was to have better control of disturbances by monitoring, better control of operators working in every station, to follow the real time production and to assure a continuous flow in production.

The assembly line for care equipment consists of 6-15 stations depending on what product needs to be assembled. Different products have different takt time at the different stations and therefore the takt time at the different stations varies depending on the product that needs to be assembled. Different production teams are responsible for each station. A production team consists of operators operating the station and one or two team leaders with the responsibility of assisting the station with any occurring problem.

The assembly line consists of eight Andon buttons. These buttons are; station understaffed, need of equipment, balancing, material shortage, quality, ramping, set rotation, operating error, training and break & meetings. When one of the Andon buttons is pressed a signal of the issue appears on an Andon screen placed high in the sealing. When the button, station understaffed is pressed, it means the station needs
more staff according to the output which needs to be achieved. The button need for equipment means there is equipment missing for the station to carry out the work task. The balancing button represents that there is not enough balance regarding the resources to assemble at the same frequency as the station is fed with a new unit. The button for Material shortage is pressed when the part to be assembled on to the unit has run out and the station needs to be supplied with more of these arts. When a defect is found in the product the Andon button, quality, needs to be pressed in order for a team leader to decide what action should be taken. When the button, set rotation, is pressed it means that it is time for the operators to switch station. The operating error button is pressed when the operator notices he or she has done an operating error which will cause a delay at the station if the error should be fixed. If the station has a new operator that are under the learning process the Andon button, training, is pressed to make the team aware of this. If a break or meeting would take place during operation hours the button, break and meeting needs to be pressed in order to make other operators aware of the situation at that station.

As an Andon button is pressed a red signal appears on one of the Andon Boards and on the team leader computer screen where the team leader is stationary. The response time after the Andon button is pressed for a team leader or vice team leader to arrive is estimated to be 10 seconds, this is however not a requirement. If 10 minutes of stop time has gone, the team leader is obliged to call the production leader for help.

In the assembly line there are two digital Andon boards centrally placed high in the selling for clear visibility. Andon board number one, shows how many units have been completed throughout the day and how many units that should have been done during the day up till now. The Andon board is updated with units completed at the end of the last station by reading a RFID code on the completed unit. This board is connected to a network, for anyone to see the real time figures. Board number two, shows; the accumulated status of the produced units compared to the planned unit schedule, seconds left of the set takt time, what station is falling behind the takt time, what station has pressed the Andon button and for how long the Andon button have been pressed.

If a unit has not been approved during production and can be fixed later the unit gets taken out of production so production can continue. The defected unit is then placed at the end of the line where it gets repaired later. Recording and saving data takes place when an Andon button is pressed. The information recorded is what Andon button is pressed, what station it regards, the source of problem and any other necessary information to describe why the Andon button were pressed in the first place. This information is noted by every team leader in an electronic journal. The recorded data is analyzed at different departments depending on what data it is that needs to be analyzed.
5 Analysis

The following chapter is divided into three main parts based on the three research questions. The first part presents the different appearances the Andon system can have. It also studies what different advantages or disadvantages these different appearances can have. In part two there is a comparison made between the two implementation models DMADV and PDCA. Lastly a model for the implementation processes to an Andon system is created.

5.1 Andon System designs

Question of issue one was how an Andon system at an assembly line can be designed. During the research the authors discovered that the Andon system can have different characteristics. The six most critical characteristics for a vehicle manufacturer to consider according to the authors have therefore been analyzed below.

5.1.1 Layout structure

The assembly line where the Andon System is operating has a two level structure. First the whole assembly line is divided into sections and thereafter the section is divided into stations. There is an option of dividing the assembly line into many or few sections and stations.

The disadvantage of creating an assembly line structure with few sections and many stations or with few sections with few stations is that the working group responsible for the section is responsible for a big line section and many different working operations. This makes it hard for operators and team leaders to create an excellent competence in every operation. A decrease in competence can lead to an increase in Andon stops and Andon stop time as chances of defects will increase. Because a team leader needs to cover a big area on the plant floor another disadvantage may be a decrease in response time, from the moment that the operator pushes the Andon button to the moment when the operator actually receives help from the team leader.

The advantage of a working group being responsible for a big section with many stations or for a big section with few stations would however be the cost cut which can be made from having less working teams consisting of less team leaders per operator.

The disadvantage of having many sections with many stations or many sections with few stations are that the costs for the Andon system will increase as there will be more team leaders per operator compare to have few but big working groups among fewer sections. The advantage of many sections and many stations or many sections and few stations is that operators can become good at all the working stations within the section as smaller sections allow operators to collect good competence within the limited section. Smaller working groups per team leader also makes it easier for each group member to be involved in group discussions i.e. reflection over quality defect.

5.1.2 Number of Andon buttons

It has been observed that there is a variation of how many Andon buttons an Andon system can consist of.
The advantage of offering one Andon button to the operator is that the operator does not need to consider what button to press. The operator simply presses the one and only Andon button the operator has to choose from. The other advantage is that the responsibility to classify of the problem is centralized to a few team leaders instead of many operators. It decreases the risk of classifying the same problem differently as fewer people categorize the problem.

The disadvantage of offering one Andon button may however be that it will take a long time for the team leader to classify the issue of why the Andon button was pressed as the team leader are usually already responsibly for noting down any possible quality issues. If this process takes too long the team leader will find it hard to note everything down at the same time as requiring of support may appear form other stations. A big risk for this to happen is especially when the Andon system is structured with few and big working sections with many operators per team leader.

The advantage of many Andon buttons for the operator to choose from when calling for help is that it reduces the team leaders work load as the team leader no longer is responsible to classify the issue problem. Instead of letting the team leader classify all the issues the operators themselves classifies the issues, leaving the team leader with more time over to support the operators. The disadvantage is however that there is a bigger risk that the same issue gets classified differently. This is because there are many people responsibly for categorizing a problem. Different people have a different understanding of what issue falls under what category. This in its turn leads to less valid data when analyzing.

5.1.3 The possibility for an operator to stop the line

There are two different scenarios that have been studied when it comes to the Andon system function. One scenario where the operators have the possibility to stop the line when a defect appears that will take longer time to solve than what the takt time allows. The other scenario is when the operator cannot choose to stop the line as a defect appears that will take longer time to solve than what the takt time will allow. In this scenario the operator can instead only choose to call for the team leader who then can stop the assembly line.

Giving the operator responsibility has both its advantages and disadvantages. The advantage giving the operator the responsibility to stop the line if any reason for stopping the assembly line is that the operators will feel totally involved and trusted with the new system. This in its turn should lead to a motivation among the operators to work with the system. By working with the system operators will try to fulfill the Andon system purpose by improving the operation. The disadvantage of giving the operators control to stop the assembly line would however be the risk of operators misusing the system. If the operators are not willing to operate together with the Andon system or perhaps misunderstand the system purpose this may happen. Operators can miss use the Andon system by pressing the Andon button more frequently than actually needed. The reason for why operators may do this is in order to get more breaks.

The same but reverse advantages and disadvantages regard an Andon system when the operators do not have the possibility to use the Andon system for stopping the assembly line. The advantages for not giving the operators the control of stopping the
assembly line is that only the team leader have the ability and responsibility to stop the assembly line. This makes the line stoppages more controlled as the line stoppages relies one person’s judgment whether the line should be stopped or not. This way the line will not get stopped for a reason that the team leader would disagree on. The disadvantage of not giving the operators the control and responsibility to stop the line is that there may be a risk to a scenario where the operators feel mistrusted and violated. There are two major reasons for why this scenario may happen. The first reason is as because the operators may feel left out from the full system. The second reason may be because the operators feel incompetent as the organization won’t trust the operators with this responsibility. Furthermore, this may lead to operators not willing to cooperate with the system by not using it.

5.1.4 Handling the defect on the spot or later
Observations have been made that there is two different ways to handle an appearing defect with an Andon system. One way to handle a defect product in the assembly line is to remove the product out form the line to deal with later. This is suitable when the takt time is so short that to fix a defect the standing still time would be too high in comparison to what the takt time is. Stopping the assembly line working on a short takt time would cause a bottle neck in the whole line leading to operators having to wait for one station to fix the defect. The disadvantage of removing a defected product from the line is that the defected product may take longer time to fix compared to if the product were to be fixed as soon as it was detected. The reason for this is that someone later on needs to spot the problem once again.

The other way to handle a defected product is to fix the detected defect on the spot and if needed stop the assembly line. The advantage of this is that taking care of the defect does not get postponed. This is good because the defect won’t be allowed to slip through one station to the next. Handling a problem when the product is finished assembly as mentioned earlier requires more time and money. The disadvantage hat may appear when stopping the line to correct the defect is that the station may become a bottle neck if the defect takes too long to correct.
5.1.5 The amount of data to record and analyze

It has been observed that different amounts of data can be collected and analyzed. There are two extreme alternative scenarios to compare where all the other cases fall somewhere in between these two scenarios. The first scenario is where the Andon user collects and analyzes as little data as possible. No data was collected or analyzed from the Andon system unless there was a reoccurring issue. Not until an issue started to reoccur more frequently the case company started to note down data to then analyze. The reason for why the company did not collect any data to analyze was because they considered data extracted from the Andon system unnecessary. Variation will always exist in the manufacturing process leading to the need of an Andon system. It is not the variation that needs to be studied but the process issues that reoccur. Doing this saves a lot of resources and focus to only analyze something that is definitely a problem. The disadvantage of only collecting and analyzing reoccurring data is however that some defects may be reoccurring without the knowledge that the reoccurring problem exists. This may be because the reoccurring problem is minor or reoccur with long periods in between.

The other scenario is the opposite form the first scenario, where the Andon user collects and analyzes as much data as possible from the Andon system. The advantage of this scenario is that all detects are collected and analyzed leading to that no defects can slip through the analyzing process. The disadvantage of collecting as much data as possible is however that it requires a lot of resources. It is also a danger of doing this as analyzers may drown in information. Analyzing too much information may lead to loosing focus on the defects that perhaps has the highest influence and therefore most important to analyze.

5.1.6 Traditional Andon signal or Silent Andon signal

Two types of Andon signals have been observed from the different case studies. One signal is the traditional Andon signal that is generated as an operator pushes the Andon button. As the Andon button has been pushed a signal requesting support is send to the team leader. The advantage of this is that the operator feels supported by the Andon system. The Andon concept is to make the Andon system your friend. This means that the operator should feel that the Andon system is a device supporting and helping the operator. The effect of this is that the operator works together with the Andon system rather than against it. The disadvantage of only having the traditional Andon signal may however be that the operator may spend more time on the operation than the takt time would allow. A possible scenario would be where the operator ignore pushing the Andon button to call for support, believing that the defect can be solved very soon when this is not the case. The effect would be that the station becomes a bottleneck slowing the whole assembly line down.
The other signal is a silent Andon signal that instead of being generated by the operator is generated when a unit at the working station takes longer time than the takt time. The advantage of this is that even though the operator does not realize that the operation is going over time according to takt time support is still sent. This prevents the station from becoming a bottle neck as the team leader in some case will be aware of the station situation before the operator realizes support is needed. The disadvantage of a silent Andon signal is however that the Andon system may be viewed as an enemy by the operator. The operator may see the Andon system as a system keeping track of every time the operator do not achieve the operation within takt time. This is a disadvantage as it reduces the working environment.

5.2 DMDAV or PDCA

The different phases for each approach can be compared to the phases of the other approach. Figure 9 presents how the different phases form the two approaches are equivalent to each other.

DMADV is basically a 5- step method with the same principle as PDCA. However, DMADV put more emphasis on gathering data and analyzing. DMADV has a clear road path whereas PDCA do not. The reason for this is because in order to help navigate through PDCA there are few tools to ensure successful identification of problems and appropriate resolutions compared to DMADV. DMADV requires much work on the technical side. The DMADV methodology has a collection of over 30 tools, some mandatory and others optional. These tools also help address issues related to the systems and structures after the project is complete, ensuring sustainability. By using statistics instead of intuition DMADV is able to provide confidence in the analysis and recommendations. For this reason, PDCA is considered a general methodology while DMADV is more specific. PDCA is for this reason also considered to be a qualitative methodology whereas DMADV is considered to be a quantitative methodology.
To be successful with DMADV and PDCA it is important that people must work in teams with experienced people. Teams without experience have the risk to end up with higher chances of failure, to improvement initiatives that are not done with from experience.

There are opportunities to combine the PDCA together with DMADV. Integrating the two models would offer a robust process improvement. Integrating PDCA with DMADV would require gaining acceptance from the key stakeholders, front line technicians, management and board members. It would also require putting control mechanisms and systems and structures in place to ensure that successful project improvement outcomes are sustained over time.

5.3 An efficient and effective Andon model

The first question of issue was how an Andon system at an assembly line can be designed. Due to the lack of literature within this area four different case studies have been carried out in order to find different ways of how companies use their Andon system and therefore how an Andon system can be design. Through the conducted interviews a good understanding of how an Andon system can be designed has been created. Instead of explaining every single part of how the Andon system can be designed the authors choose to focus on the big differences an Andon system can have in appearance, function and in the implantation process. Together with the analyzing of the implementation model DMADV and PDCA this has created an implementation model to an Andon System.

5.3.1 5.3.1 Implementation Model to an Andon System

In the start of an Andon implementation the company recommended to approach the Andon implementation project with choosing an implementation model. In this case DMADV or PDCA as analyzed here above. In the first steps of the implementation process the following observation should be taken in to consider and evaluated:

The first observation the authors noticed how the physical layout could be structured. The assembly line could either be divided into many of few sections and stations. The advantage of dividing the assembly line into many sections with few stations were that the operators can become good at the few working stations they operate on instead of becoming mediocre on many working stations. The second advantage of many sections few stations are that each operator becomes more involved in team discussions during analyzing. However, the disadvantage speaking against many sections few stations is that it is more expensive compared to many sections few stations, as more team leaders would be needed.

The second observation the authors noticed was how the number of Andon buttons an operator can chose form. By giving the operator only one Andon button to press on the responsibility of categorizing the problem were centralized as only team leaders then have the authorization to categorize a problem. The advantage of this is that if the same problem would appear chances that the problem would be categorized the same would be bigger compared to if two different persons were to categorize the same problem. The downside was however that the team leader is required to do many things that may lead to delay in help.
The third observation was that sometimes the operators had the possibility stopping the assembly line whereas in some cases this was not the case. By giving the operator the responsibility to stop the assembly line operators feel more involved trusted and motivated. The risk is however that unless the operators fully understand the purpose of the Andon system and the function to stop the assembly line over or underutilization can appear.

The fourth observation was that a defect can be handled differently. In some cases, it can be rational to put the defected product aside in order to avoid the risks that a bottleneck appearance. In other cases, the defect product is left in production to be handled as soon the defect has been observed.

A fifth observation is that different amount of data can be collected to be analyzed. Some Andon systems may record as much data as possible to make sure every single defect will be prevented from reappearing. Whereas some Andon systems only record reoccurring defects to make sure time has not been spent on analyzing a defect which could not have been prevented.

Lastly observations were made how there were two Andon signals (traditional and silent). Traditional Andon signal allows the Andon system to become the operator’s friends. Whereas the silent Andon signal made sure not to allow a single second above the set takt time to go over time until Andon signal was sent out for help.

After evaluation of this six observation the model is only completed if the company continues with the phases of the implementation model DMADV or PDCA to the final phase, or earlier has used the opportunity to combining the two models.
6 Discussion and Conclusions

This chapter discusses the thesis result and the methods used in order to reach the result. Secondly implications of the thesis result are then described. Thirdly conclusions and recommendations to the thesis results are made. The chapter ends with suggestions on further research.

6.1 Discussion of Result

The purpose of this thesis was to develop an implementation model to an Andon system, which makes the implementation efficient and effective on a vehicle manufacturing assembly line. From the purpose, three questions of issue were created. The results to each question of issue are reflected on below.

6.1.1 Andon System Design

The purpose of the first question of issue was to create a good understanding among the authors of how an Andon can appear. By studying four different case companies this purpose is believed to have been fulfilled. Due to time limitation the authors have chosen to focus on the six most important characters for vehicle manufacturers to analyze. Through interviews with various responsible people at the different case companies, an understanding of what the most important characteristics could be identified. As the more important characteristics were identified a deeper understanding of these characteristics were made. It was soon discovered that these characteristics could differ. An understanding was then created on how these different characteristics differed.

It is important for a vehicle manufacturer to consider how many sections the assembly line should consist and how many station each section should contain. The reason is because the number of sections and stations at an assembly line has a direct relation to how many operators a working team consist of. The outcome of how successful an Andon system can be, partly depend on the group size.

The different number of Andon buttons an operator can choose form is an important part of designing an Andon system. Depending on how many categories an operator can classify a problem has a relation to how correct the extracted data will be. It is also important due to the reason that different many Andon buttons occupies different amount of time when classifying the problem.

In some cases, the Andon system creates the responsibility among the operators to stop the line when a defect appears. However, this is not always the case as some Andon systems have been observed to be designed to not have the option of stopping the assembly line as a defect appears. This is important to consider as it affects the strategy to handle a detected defect.

It was observed that different Andon systems handle defects differently. It is important to decide how a defect that has been detected should be handled as this decision can have an impact on cost and the required time to handle a problem.

The amount of collected data which is analyzed can differ in amount. Should consider what type of data is relevant to analyze. Why this is important is because a lot of data may require a lot of resources and time to analyze. On the other hand very little amount of data may lead to unrecognized problems within the assembly line.
It has been discovered that an Andon signal can be designed with two different types of signals. One visual signal generated by the operator and a second silent signal, automatically generated by the Anson system itself. Because both signals have advantages but may not be suitable for every manufacturer depending on a wide range of other factors such as knowledge maturity, vehicle manufacturers need to consider what type of Andon signal the Andon system should be using.

6.1.2 Models for implementation systems today

The authors have chosen to analyze two different implementation models. The two models were DMADV and PDCA. These two implementation models have been chosen to analyze as the authors believed these two models were the two most appropriate models to study. The reason for this was as the two models were the most general and commonly used implementation models according to literature research.

The models are quite similar with a few exceptions. The exceptions have been analyzed against each other in order to find strengths and weaknesses from both models in relevance to an implementation model for an Andon system.

6.1.3 An efficient and effective model for implementing Andon

The authors designed this question so it could be answered from analyzing the answers from question one and two together with all information gathered from the interviews, surveys and research. Due to the complexity and individuality of the question the authors had to interpreting and categorize the answers in to models for how the preferred to work with Andon and how they could improve the Andon implementation. The purpose of the question was to give a final answer to the thesis purpose: “To develop an implementation model to an Andon system, which makes the implementation efficient and effective on a vehicle manufacturing assembly line”

This gave the thesis chapter 5.3. This was made from experiences from the case companies and theoretical frames from the implementation models.

Andon system cannot be standardized or compromised due to the purpose to give the best production feedback and quality improvements. That is why the authors’ focus on the model how to, and in which steps, evaluates how the Andon system should be physically designed.

The base of PDCA was the best ground to start on in the authors opinion, this due to its straight forward and logic thinking and that it could be divided in to steps collected from interviews, surveys and research. One of the case companies that were interviewed mentioned that they work with PDCA daily as a part of their project process. This is a good confirmation that the model is appropriate and well suited to work with when process and implementation are similar.

The authors think that a company that decided to implement an Andon system on their vehicle manufacturing assembly line now have a tool to work from instead of have to do and construct the process of the hole implementation by themselves. This saves them quality and time that in the end will lead to better profit. All this from evaluating and highlighting improvements and downfalls of different Andon systems.
6.2 Reliability and Validity

A valid study is when data is properly collected, so that the conclusions accurately reflect and represent the real world that was studied. Even though the result may be reliable and valid questioning the reliability and validity still needs to be made (Yin, Qualitative Research from Start to Finish, 2011).

To achieve this, the authors first collected rich data by interviewing relevant individuals within each case company. Data was received through qualitative interviews which assured the authors as much data as possible were received as this form of interview technique allows the person being interviewed to speak freely during the interview. This allows the interviewers to receive more information that what perhaps the interviewers knowledge contains.

After the information was collected a second checkup with the interviewed person was made in order to make sure the collected information was accurately mirrored the real world where the information was collected from.

Third and lastly a comparison was made between the information collected from different sources within the same case company. Therefore, even though the data is secondary the authors consider the data to be highly reliable as the collected data has been confirmed by more than one source.

6.3 Conclusions

Due to the lack of existing literature regarding the implementation and usage of Andon on a vehicle assembly line a need of an Andon implementation model was identified. The purpose of this thesis was therefore to develop an implementation model to an Andon system, which makes the implementation efficient and effective on a vehicle manufacturing assembly line. In order to fulfill the purpose the purpose was broken down into three research questions.

The first research question was; how an Andon system at an assembly line can be designed. This research question was answered by identifying six subsections of different Andon layouts as well as identifying the pros and cons of each layout.

The second research question was; what the contemporary models for implementing systems are. The answer to this research question was that the usage of the PDCA implementation model would be most suited for an implementation of an Andon system and how it can be used as a base of the implementation project for the implementation team.

The third and last research question was; How an efficient and effective implementation model for an Andon system can be designed. For this research question, the authors described the whole implementation model as one project. This offers the implementation team a vital instruction on how to handle the implementation.

Because interviews have been conducted on different companies with employees from different positions, a wide spectrum of impressions, experiences and tactics have been collected in the model.
6.4 Further Research

This study focuses on six different Andon system features and how they may differ. According to authors knowledge this is the six most essential features for a vehicle manufacturer to be aware of that may differ in an Andon system. It is however important to highlight that this study do not mention all features of an Andon system. It may therefore be suggested to study other features of the Andon system.

Secondly analyzing the differences in how the Andon system can appear has been done based from interviewers. The interviewed person has given positive and negative feedback on all the different features of the Andon system. By relying on the interviewed persons feedback analyzing and eventually a result have been shaped. Due to time limitations the authors have not have had time to investigate themselves what the advantages and disadvantages are of the different features. Therefore, it is suggested that further investigation is made on how the different features of an Andon system performs.
7 Bibliography


Biography


Joseph, M. A. (n.d.). *Designing a qualitative study needs to refer as a second hand reference*.


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Attached files

The final chapter presents attached files that have been used during the research work. Firstly, the Andon survey is presented which the authors created. This is followed by relevant collected pictures that have permission to be presented by the case companies.

Attachment 1 - Survey questions

The figure presented below is a copy of the questions used during the interviews at the different case companies.

**Andon Survey**

As this is a qualitative study we would appreciate if the answers are well formulated and do not be afraid of answering long answers, as the more information you provide the more valid our result will become.

**Questions:**

- For how long have you had Andon and why did you implement it at this/this line/stations?

- How long did the implementation process take?

- What different steps was the implementation of Andon carried out in?
  (For example, realizes problem, analysis of possible solution, deciding Andon, creating Andon team, physical implementation, implement software, educating operators, ready for use and so on)

- How is Andon used in your company?
  (For example, do you use Andon as a part of just-in-time to view status of production or is it used as a signal system identifying defects)

- Were there any problems with the Andon process at start? And what was the most challenging part?
  (For example, do the operators work well with the system, if not what may be the problems)

- Is there any difficulties with running the process at the moment

- What is the most important aspect to keep in mind when implementing - and then also running an Andon system?

- How does the Andon process look like (What happens after the Andon button/ chord is pressed)

- What information get extracted from an Andon system and how does the information get recorded
  (For example, does the information get recorded manually or automatically?)

- What information do the Andon board provide
  (For example, items produced, items left to produce, status on the different stations)

- What information is most important to show on the Andon Board
Attachment 2- Andon Board from Illumination Case Company
The following figure presents the Andon board from the illumination Case Company.

Attachment 3- Andon Board from Gardening Case Company
The following figure presents the Andon board from the Gardening Case Company.