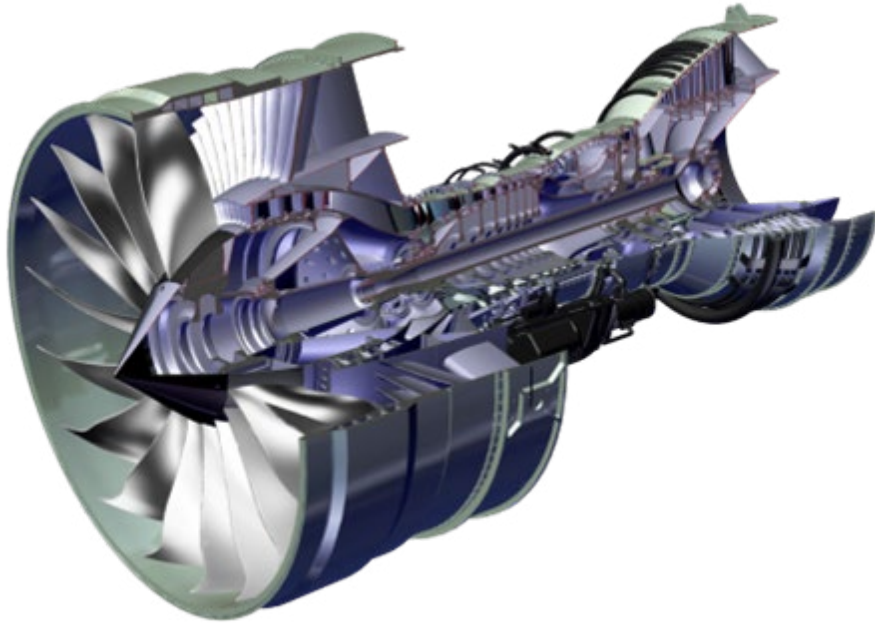




CHALMERS



Enhancing Problem Solving by Improving the Identification of Root Causes to Avoid Reoccurring Non-conformances

A Case Study Performed at GKN Aerospace Sweden

Diploma work in the Master programme Quality and Operations Management

CHRISTOFFER ASK
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Abstract

GKN Aerospace is the first tier supplier to the global aviation industry and produces products with a great complexity and quality. However, GKN is as many other producing companies confronted with internal reoccurring problems in the manufacturing. Reoccurring problems consume resources in terms of material and time for the employees. This case study was made with the purpose to identify possible improvement areas for the problem solving process at GKN in order to make it more robust.

GKN are aware of that they have reoccurring non-conformances in manufacturing, they are measured, but the level is quiet constant. Through interviews, survey and review of internal documents the researchers found that there is room for improvement for the information collected and documentation. The initial documentation of non-conformances is sometimes poor. In addition, the problem characterisation made in the documentation template PPL is occasionally performed poorly, lacking useful information. The following root cause analysis has sometimes shortcomings in the method of breaking down the causes to identify the root cause. The literature study made suggests a more extensive way of working with the root cause analysis tool 5 Why, compared to how GKN works today.

By studying the prerequisites to identify the root cause the authors found some possibilities for improvements. More time is needed for problem solving. Currently the time is insufficient, 95 % of the Production Engineers agree upon this. Further, the Operators must be more incorporated in the problem solving to understand the purpose of performing a good problem solving. They need to get proper education on the subject in addition to their expertise. In general the thesis concerns the understanding of how information is used and affects the problem solving as a whole. At GKN training is needed to emphasize the importance of problem characterization, to be able to identify root causes for problems.

What GKN gains on illuminating focus on the problem characterization, the problem descriptions and the root cause analysis with improved prerequisites, is that GKN improves the process of identifying root causes of problems and thereby can avoid reoccurring non-conformances.

Keywords: Problem Solving, Practical Problem Solving, GKN Aerospace, Root Cause, Root Cause Analysis, 5 Why, Reoccurring Non-conformances

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Christoffer Ask and Maria Trygged, Gothenburg, May 2016

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1

Introduction

In this first chapter, the background of the company is described, followed by the purpose of the research and the research questions. The chapter ends with the delimitation of the thesis.

1.1 Background

GKN Aerospace Engine System group (GKN) derives from a small ironworks in Wales that started its business in 1759. Volvo Aero Corporation was acquired by GKN in 2012 and contained locations in Linköping, Kongsberg and Trollhättan. Trollhättan is where the headquarter of the company is located (GKN Aerospace, 2016a).

GKN has 90 years of aerospace experience and is today one of the key competitors of the independent first tier suppliers at the global aviation industry. They have roughly 17 000 employees spread out on their 61 locations across the globe (GKN Aerospace, 2016a). GKN offer complex and high-performance components and assemblies for aerostructures. They manufacture engine products for commercial aviation and air force, they make wiring systems and landing gear. The company offer ice protection systems as well. Further, GKN sell special products including glass, acrylic and polycarbonate transparencies (GKN Aerospace, 2016b).

The company has a level of non-conformances which shows no identified trend to becoming fewer. GKN at Top Management level has a goal called *Road to Zero* which aims to reduce the non-conformances that is received by the customers, both identified and unidentified and to reduce the reoccurring non-conformances (Andersson, 2015). GKN value problem solving highly. To begin with they think it is important because if there are no problems there are no opportunities, meaning no room for improvement and that in itself is considered a big problem (Knuts, 2015). See Figure 1.1 for a figure explaining GKN's view of opportunities with problems.

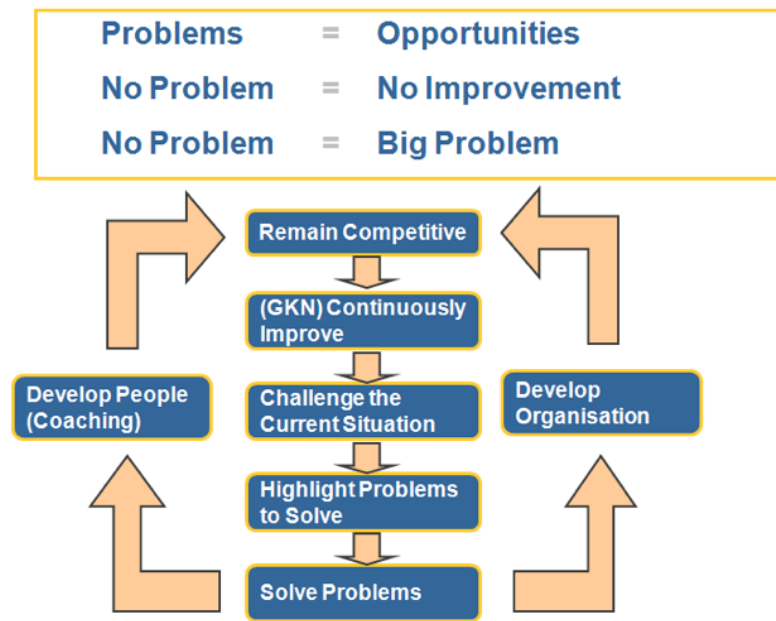


Figure 1.1: Problems and opportunities

Source: Knuts (2015)

GKN strives for having a problem solving culture where they have created a common language, ensured consistency, enabled knowledge transfer and sharing, and where the employees are involved. This point of view is valuable for this master's thesis. The company has given a lot of thought into problem solving and it is highly valued since working with it gives the capability to attack and solve problems when and where they occur efficiently (Knuts, 2015).

1.2 Purpose

The purpose of this thesis is to suggest improvement areas to make the problem solving work more efficient and to avoid reoccurring non-conformances in the manufacturing at GKN.

1.3 Problem Description and Research Questions

A factor for reoccurring non-conformance is when the root cause behind a non-conformances has not been investigated sufficiently. Therefore, the following research questions have been formulated to get a clearer picture of the situation of the problem in the production at GKN:

RQ1 - How do GKN work with identifying the root cause of problems in manufacturing?

The purpose of this question was to investigate and map how GKN currently is working with problem solving and identification of the root cause.

RQ2 - What would an improved process of identifying the root cause look like?

This question was answered after the authors had performed a literature study, interviewed employees, performed a survey and revealed possible inadequate parts of the process of finding the root cause. This creates a picture of an improved future state.

RQ3 - What can GKN do to improve the identifying of the root cause?

This helps to see how GKN can eliminate the gap that is now standing between the current state and the improved future state of identifying the root cause.

1.4 Future Work and Delimitations

The study concerns the problem solving in manufacturing. The study took place at GKN's facility in Trollhättan where the production is located. GKN has facilities all around the globe, but with the given time boundary this was the only location under the loupe.

The study was delimited from investigating non-conformances identified by customers and caused by suppliers. These choices were made since the manufacturing cannot improve the inbound material and because the non-conformance identified by the customers were managed by the Quality Department and those are significantly fewer. Focusing on them would have less impact on the overall problem solving and root cause culture in the company than the ones chosen.

The study was delimited from analyzing the process of creating and implementing the countermeasures for root causes. The time boundary limited the researchers from investigating how the identification and implementation of countermeasures could be improved in depth.

2

Theory

This chapter covers theory related to problem solving and root cause analysis.

2.1 Definition of a Problem and Problem Solving

A problem is defined according to the Aerospace Standard AS13000 (AS13000) as a: *"Description of an issue where a product does not meet the required standard"* (SAE International, 2015, p. 2). Pounds (1969) explains it simpler: *"[...] a problem is the difference between an existing situation and the desired situation"*. Both agrees that a problem is a state deviating from the ideal and where actions are needed to avoid deviation in the future.

Humans are constantly confronted with difficult situations those contain obstacles which have to be overcome in order to reach a goal. To remove these obstacles it is desirable to have a process of generated knowledge to solve the difficult situation (Dostál, 2015). One point to make according to Duncker and Lees (1954) is that a problem come to existence when a person has a specific aim but does not know how to reach it. Also, there has got to be an awareness of the problem. Otherwise there is no potential in finding a solution. Further having a will to handle the problem is of great importance. Problems should be given to people who willingly accept them and in case they do not they need to be helped with the motivation to solve the problem. Emotional factors also play an important role such as interest, self confidence and the person's opinion of his/her ability (Mayer, 1998).

According to Dostál (2015) a person has to first identify the problem and after that seek its possible solutions. During problem solving 3 phases are being experienced:

- *A recognition of a situation that is problematic.*
- *The phase of the solving process. At this phase the subject looks at the properties of the situation and searches for resources those can change the situation with respect to the aim.*
- *The verification phase of the discovered method or property and its usability for similar problems.*

Dostál (2015) argue however that *"the situation is even more complex and needs more analysis"* (p. 2802).

2.2 Problem Solving Methods and Tools

Problem solving is always in the focus for engineers. Today companies use standardized problem solving strategies, Six Sigma, 8D and A3 are just some examples (Eba, 2016).

At GKN three major problem solving methods are used. A PPL sheet is used, which is a version of A3. Further 8D is used and Six Sigma. There are several differences between these strategies mentioned below, however the most evident one is that A3 and PPL are designed for less complex problems while 8D and Six Sigma are made for problems with a higher level of complexity.

2.2.1 PDCA

The PDCA cycle, which stands for Plan-Do-Check-Act, is a cycle of four steps that is iterative and used as a practice for improvement (Bergman & Klefsjö, 2010; Liker & Franz, 2004; Pietrzak, 2015).

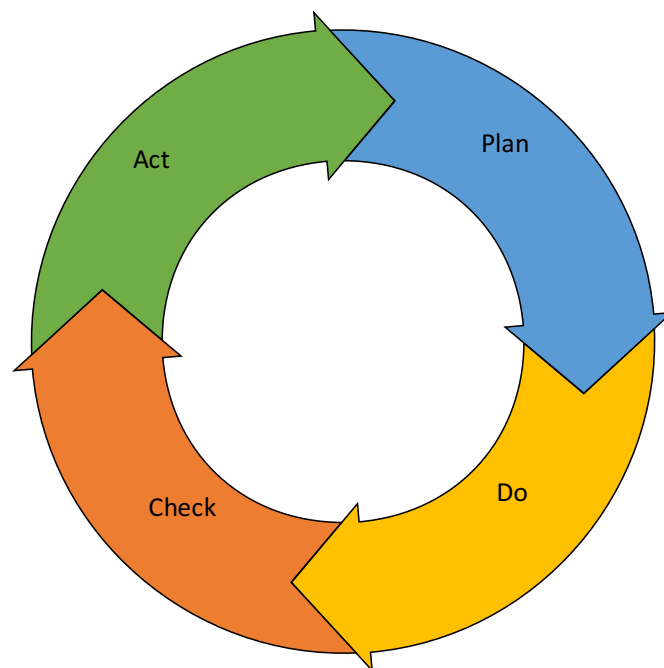


Figure 2.1: The PDCA cycle

The first phase of the cycle is the Plan phase. In this phase it is of great importance to state what is wanted to accomplish. Further at this step one should define how to know when the mission is accomplished. A PDCA project should not proceed unless there is a set plan that contain objectives those are measurable, possible to reach and that has determined methods to use (Bergman & Klefsjö, 2010; Liker & Franz, 2004; Pietrzak, 2015). To quote Albert Einstein: *"If I had an hour to solve a problem I would spend 55 minutes thinking about the problem and 5 minutes thinking*

about solutions."

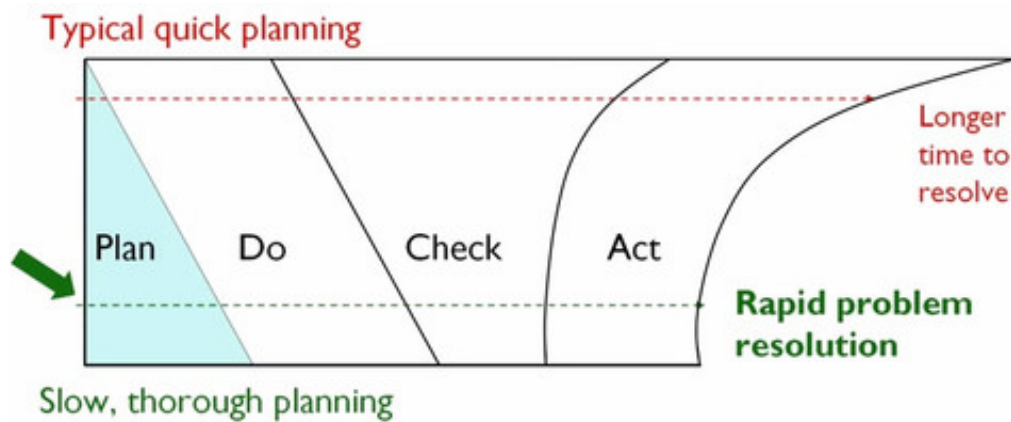


Figure 2.2: Importance of proper planning

The failure to plan properly almost always results in longer times to resolve the problem. The hastiness in rushing through the plan phase will have to be paid for in the check and act phases. When doing a slow thorough planning they are far more likely to solve their problems faster and far more efficiently as illustrated in the picture. This is why Practical Problem Solving is so powerful (Liker & Franz, 2004).

In the Do phase what was planned to be done should be done. As for the Check phase one should check how well the expectations have been accomplished, meaning observe what the effects have been and the result that has been achieved. Can a deviation be seen from the plan? In the Act phase one should consider lessons learned from performing the cycle. Which parts of it, methods etc, were successful in order to reach the goal and which were not? If there were parts those did not function the implementation should be corrected (Bergman & Klefsjö, 2010; Liker & Franz, 2004).

2.2.2 Six Sigma

Six Sigma is a structure that reduces variation in organizational processes by improvement specialists (Schroeder, Linderman, Liedtke, & Choo, 2008). It uses a structured problem-solving methodology that is called DMAIC which stands for *Define, Measure, Analyze, Improve and Control*. This methodology is used for more complex problems when the cause and solutions are not evident. In a Six sigma project people with different knowledge and experience are brought together. For more simple problems one person can often solve a problem by himself without all of the DMAIC steps (George, Rowlands, Price, & Maxey, 2005).

2.2.3 Practical Problem Solving

Practical Problem Solving (PPS), see Figure 2.3 was introduced by Toyota as part of Toyota Business Practice, as developed from the PDCA. The practical problem

solving require before analysing the root cause to clarify the problem, to "grasp the situation". To clarify the situation, you need to start with a visit to where the problem is. At that point a target for the improvement should be set. Then the problem is broken down to the "real problem" and not just symptoms of the problem. Then questions are answered such as: Where is the problem observed? Where is the likely cause? First then, the countermeasure is generated and implemented. The countermeasure is then evaluated, if the countermeasure is effective it should become standardized in the process. The seventh step, standardization of the new process is very important, since it drives the continuous improvement and learning (Liker & Franz, 2004).

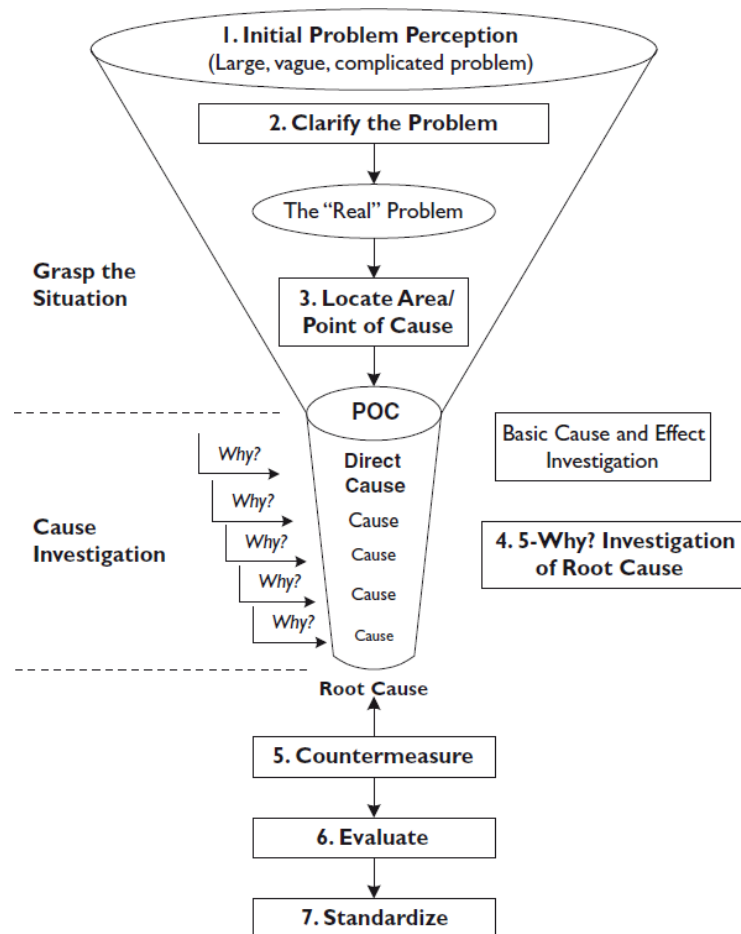


Figure 2.3: Toyota's practical problem-solving process

Source: Liker and Franz (2004)

2.2.4 8 Disciplines - 8D

8D is standard similar to PPS but is by far detailed compared to the PPS in what information that is required. The structure is as follows: Plan the approach meaning considering the group members, time frame and resources needed. Then comes the building of the team, the description of the problem, the implementation of a temporary fix, the identification and elimination of the root cause, the verification of the

solution, the implementation of a permanent solution, the prevention of recurrences and finally the celebration of the team's success (Tools, 2016).

2.2.5 5 WHY

The 5 Why tool is helpful when there is a need to determine the relationship between cause and effect in a problem. It is useful when the cause of a situation or a problem is unclear. The tool is quite simple to use and does not require a detailed investigation. It is a simple form of a root cause analysis (Liker & Franz, 2004; Sondalini, 2016).

The reason why the tool is called 5 Why is because the users of it are supposed to ask the question why repeatedly five times in order to peel off layers of symptoms and issues those can lead to the finding of the true root cause. However, it may not be certain that the root cause has been found unless real evidence can confirm it (Sondalini, 2016).

The method works as follows: A statement of a situation is formulated and then the question why it occurred is asked. The answer to this question is then turned to a second why. Further the answer to the second question becomes why question number three etc. By continuing asking why and not being satisfied by each answer the chances of finding the true root cause increase. However to ask five times is not a must but rather a rule of thumb. Fewer or more whys may be asked before the root cause of the problem has been found, but "there is a school of thought that 7 "whys" is better, that 5 "whys" is not enough to uncover the real latent truth that initiated the event" (Sondalini, 2016).

Something to consider is that a problem can have several different causes. To use just a "Why table" is only permitted when there is one single cause of each effect that is listed in the Figure 2.4. If there are more causes to an effect it should be illustrated in a "Why Tree", see Figure 2.5. The tree visualizes all the causes of the failure event in a clear way. There is a risk of not reaching a root cause if the tree is not used. If you go the wrong direction you will fix the wrong thing and leave the true root cause behind. "Questions can always be answered, but that does not mean that the answer is right, or that all necessary causes of the problem are identified" (Sondalini, 2016, p. 2). It is not realistic to perform a 5 Why analysis by only completing a 5 Why Table of questions and expect it to lead to the wanted root cause. All cause and effect branches to the root cause/s are needed. To begin with the Why Tree should be drawn on one level at a time and the questions for each level should be asked to find the right failure path of the causes.

In order to make this tool useful real evidence is required with a logic flow and discipline in order to find the root cause of the investigated problem. If the investigators do not have the real evidence they should stop the analysis search for proof. There is no point in going further without evidence since all work from there will be opinion, speculation and guesswork. It should be made a requirement at a company to keep

2. Theory

the evidence safe, always. With the real facts and evidence the whole story will be uncovered down to its real roots and then they can be deleted (Sondalini, 2016).

5 Why Question Table			
Team Members:		Date:	
Problem Statement: On your way home from work your car stopped in the middle of the road.			
Estimated Total Business-Wide Cost: Taxi fare x 2 = \$50, Lost 2 hours pay = \$100, Order was late to Customer because Storemen did not get to work in time to despatch delivery and Customer imposed contract penalty of \$25,000, Lost Customer and all future income from them, estimated to be \$2Million in the next 10 years.			
Recommended Solution: Carry a credit card to access money when needed.			
Latent Issues: Putting all the money into gambling shows lack of personal control and responsibility over money.			
Why Questions	3W2H Answers (with what, when, where, how, how much)	Evidence	Solution
1. Why did the car stop?	Because it ran out of gas in a back street on the way home	Car stopped at side of road	
2. Why did gas run?	Because I didn't put any gas into the car on my way to work this morning.	Fuel gauge showed empty	Contact work and get someone to pick you up
3. Why didn't you buy gas this morning?	Because I didn't have any money on me to buy petrol.	Wallet was empty of money	Keep a credit card in the wallet
4. Why didn't you have any money?	Because last night I lost it in a poker game I played with friends at my buddy's house.	Poker game is held every Tuesday night	Stop going to the game
5. Why did you lose your money in last night's poker game?	Because I am not good at 'bluffing' when I don't have a good poker hand and the other players jack-up the bets.	Has lost money in many other poker games	Go to poker School and become better at 'bluffing'
6. Why			

Figure 2.4: Example of a 5 Why Table

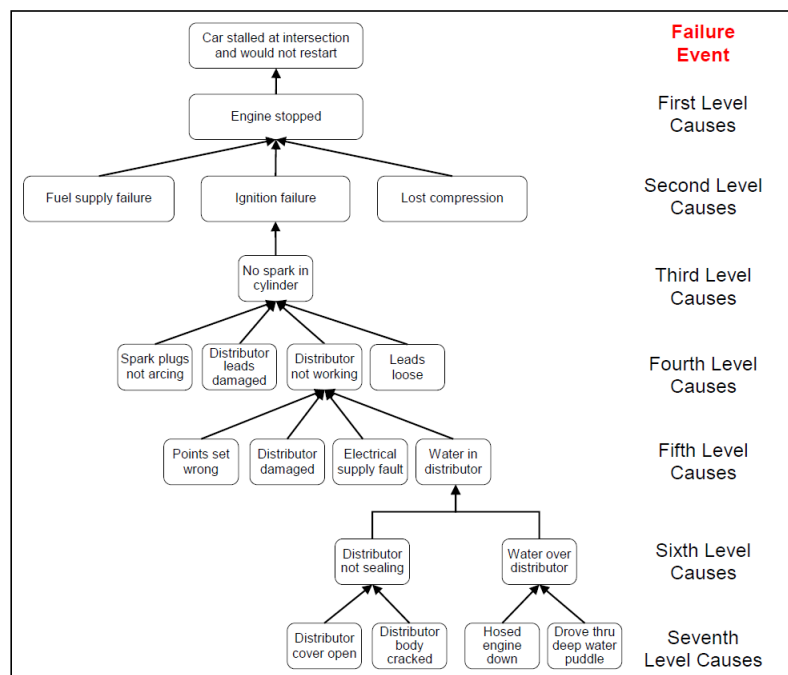


Figure 2.5: Example of a 5 Why Tree

2.3 The Cornerstone Model

The Cornerstone Model by Bergman and Klefsjö (2010) outlines the basis for the Total Quality Management (TQM). The cornerstones of TQM are described as the following: focus on customers, focus on processes, continuous improvement, base decisions on facts, letting everybody be committed and last but not least a Committed leadership (Bergman & Klefsjö, 2010). See Figure 2.6 for an illustration of the Cornerstone Model. All parts of the model have an influence the quality mindset and are connected to the problem solving, which is why they are relevant for this thesis.

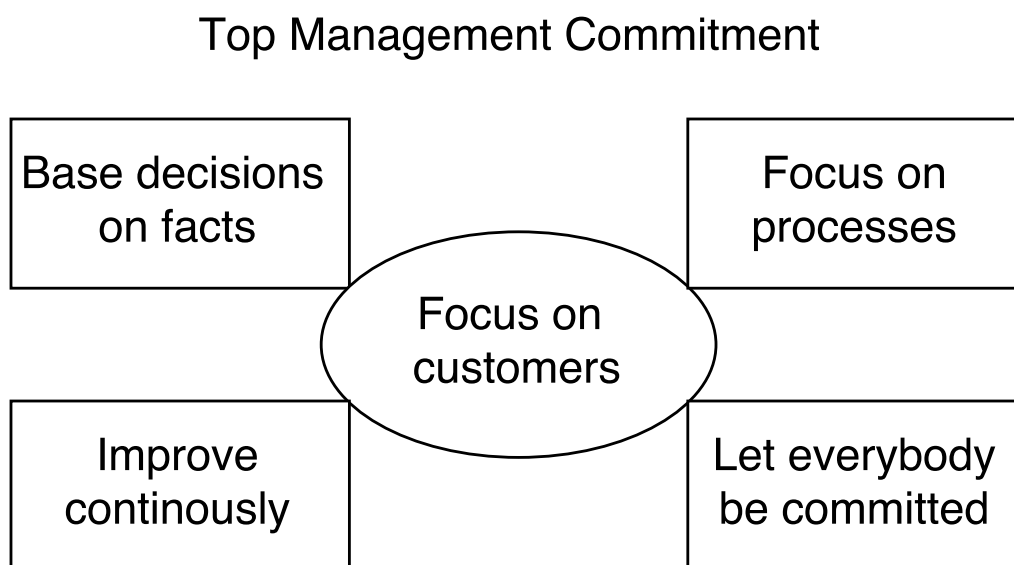


Figure 2.6: Cornerstone Model

Focus on Customers

Companies today must deliver products and services with a perceived high quality for the customers, or they will not survive in the future. A lot has changed since the beginning of the industrial revolution, when almost all products produced were sold. Today organizations must focus on the customers and put their needs and expectations into consideration (Bergman & Klefsjö, 2010).

The quality of a product or service lies in the perception of customers. "Focusing on the customer implies finding out what they want and need, and then to systematically try to fulfill these needs and expectations when developing and manufacturing the product" (Bergman & Klefsjö, 2010, p. 38).

Bergman and Klefsjö (2010) also argue that focusing on the customers do not only apply for external customers, the buyers or users, but also for the internal customers. All companies and organizations have internal customers, the employees. Their needs do also have to be satisfied in order for them to make a good job. If

the internal customers are satisfied and proud of their work, the external customers will also be satisfied in the long run.

Base Decisions of Facts

To base decisions on facts is an important element of modern quality philosophy, to not let random factors be of decisive importance. To do this, requires knowledge about variation and distinguish between natural cause variation and special cause variation. The factual data is both of numerical and verbal character (Bergman & Klefsjö, 2010).

In history facts are rarely used to draw important conclusions about the manufacturing process even though it was collected. Today, it is important to have a strategy for making decisions based on facts in relation to manufacturing. Basing decisions on facts implies to actively looking for relevant information, which can be compiled and analyzed, from the analysis conclusion can be drawn for improvement (Bergman & Klefsjö, 2010).

Example for simple tools for structuring and analyzing data are the Seven QC Tools and the Seven Management Tools.

The Seven QC Tools

- The Control Chart
- Pareto Chart
- Scatter Plot
- Data Collection
- Stratification
- Histogram
- Cause-and-effect Diagram

The Seven Management Tools

- Affinity Diagram
- Tree Diagram
- Matrix Diagram
- Interrelation Digraph
- Activity Network Diagram
- Matrix Data Analyze
- Process Decision Chart

Focus on Processes

Generally activities those are organized and repeated in time can be looked upon as a process. The objective for a process is to create value for its customers. That is being done by a transformation of inputs, such as material or information, to an output in the shape of either goods or services. The value that is being created, or the result of the process, is supposed to satisfy customer needs. The process

should be efficient and satisfy needs and still use as few resources as possible. It is important to identify the suppliers of a process and to provide what is needed in the process to minimize the amount of resources and also to satisfy the customer needs (Bergman & Klefsjö, 2010).

A process can link the past with the future. This is done by the generating of data that is indicating how well the process is performing in terms of customer satisfaction. By using statistical tools one can draw conclusions from the history of the process about its results in the future. This gives information on how to improve the process. Looking at data over time in this way is useful (Bergman & Klefsjö, 2010).

Improve Continuously

Today external customers have a demand for quality which continuously is growing. This is not very strange considering that we are living in a world where new solutions for technology etc appear with a more rapid pace than before. Because of this continuous improvements concerning quality of both services and goods those are produced by companies are of vital importance. Bergman and Klefsjö (2010) summarizes improvement quite well: *"Anyone who stops improving soon stops being good."* (p. 43).

A basic rule of thumb of continuous improvement according to Bergman and Klefsjö (2010) is that it always is possible to improve products and processes and managing to do so using fewer resources. A useful tool for continuous improvement is the PDCA cycle which will be elaborated on further later on in the report.

Let Everybody be Committed

To make sure that quality work becomes successful it is very important to create conditions enables participation in the work with improving continuously. It is essential to facilitate the opportunities for the employees to both be committed but to also participate in an active way, both in improvement work and decision making (Bergman & Klefsjö, 2010).

Committed Leadership

It is important to have a committed and strong leadership in order to create a culture that enables for quality improvements. Further it is essential to point out that the committed leadership should be practiced on all of the levels in the organization (Bergman & Klefsjö, 2010).

What management needs to do is to, in the company vision, include quality aspects and further to support the activities those regard quality financially. Further Management should take part actively in the process of improvement. This is significant. Management should stress the importance of quality as much as delivery

times and direct costs etc. If they do not it is not very likely that the employees will be committed to working with quality (Bergman & Klefsjö, 2010).

2.4 Prerequisites for Problem Solving and Root Cause Analysis

The following section cover some important prerequisites to get a well functioning problem solving and root cause analysis.

2.4.1 Business Creativity and Motivation

Creativity in business foster innovation, drives improvements of processes and products. Creativity is more than just thinking imaginatively, it requires expertise and motivation. According to Amabile (1998) to obtain creativity for an individual, all the three components: expertise, motivation and creative thinking skills have got to be fulfilled, see Figure 2.7.

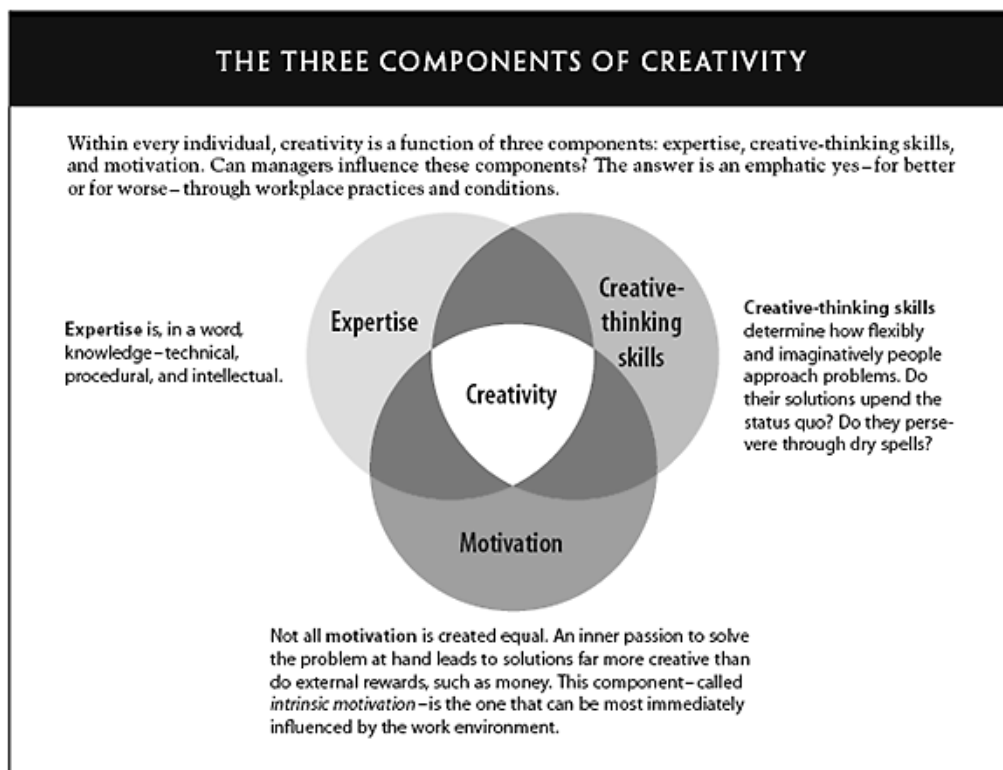


Figure 2.7: The three components of creativity

Source: Amabile (1998)

2.4.1.1 The Three Components of Creativity

Expertise encompasses everything that a person knows and can do in the broad domain of his or her work (Amabile, 1998, p. 78). Creative-thinking skills refer to how people approach problems and solutions, how they take existing knowledge into new ideas. A human will be more creative if she feels comfortable disagreeing with others and seeks solutions outside the status quo (Amabile, 1998). It is however the third factor, motivation that determines what people actually will do regardless of the creative thinking skills or expertise. If there is a lack of motivation, new creative perspectives will not be generated (Amabile, 1998).

There are two factors of motivation which are important to distinguish, extrinsic and intrinsic. The second one is by far more essential for creativity (Amabile, 1998). Extrinsic motivation comes from outside a person (Amabile, 1998). This kind of motivation makes a person perform a job to get something or to avoid something undesirable, typically in the form of a reward. The extrinsic motivation may boost creativity, but research shows that it only works in the short run, if it works at all. Some people may get the opposite effect of extrinsic motivation and get less creative because of the pressure. What is far more effective is passion and interest. A person's internal desire to do something, that is what intrinsic motivation is all about (Amabile, 1998). When people are intrinsically motivated, they are engaged and enjoy the challenge of work.

There is no doubt that most people want to make a real effort given that they feel that they have something to gain on it. It is a prejudice to think that job satisfaction and productivity are incompatible. This prejudice is built on the idea that people by definition are uninterested and unengaged in working. The cases those seem to confirm this old fashioned view tend to take place when the ruling style of management is dominant and when the administration and personnel policy that is applied inhibit the engagement and the ability of initiative. This contributes to that we, on our workplaces, find people who seem to be uninterested in their work, who do not have any ability to take initiative or responsibility to any greater extent. It is important that an employee feel both that the value of reaching the goal, in terms of effort that the person is willing to invest, is high as well as the size of the reward (Rubenowitz, 2004).

2.4.1.2 How Management Can Influence Creativity

Managers can affect and influence all the three components of creativity, but expertise and creative-thinking skills are more difficult and time consuming to influence than motivation. There are six general categories managers can affect that influence creativity: challenge, freedom, resources, work-group features, supervisory encouragement, and organizational support (Amabile, 1998).

Challenge

Challenge is about matching people with the right assignments. Amabile (1998) ar-

gue that *"Managers can match people with jobs that play to their expertise and their skills in creative thinking, and ignite intrinsic motivation. Perfect matches stretch employees' abilities. The amount of stretch, however, is crucial: not so little that they feel bored but not to much so that they feel overwhelmed and threatened by a loss of control."* (p. 81).

Freedom

Regarding freedom the key to create creativity is by giving people autonomy to choose (Amabile, 1998). For instance, give people guidelines for certain tasks and let them choose within certain boundaries. To give people the authority to choose how to approach problems motivates people to work harder.

Resources

According to Amabile (1998) there are two main resources that affect creativity: time and money. These need however to be allocated carefully, which is hard. Time pressure can during short periods boost creativity, but in the long run it will hinder creativity and can lead to stress and a reduction of creativity. Organizations routinely kill creativity with impossibly tight deadlines (Amabile, 1998). Managers need to allow time for exploration to create creativity.

Work-group Features

Teams that are creative have a diversity of perspectives and backgrounds. The combination of different expertise and creative-thinking skills often results in new ways of seeing things. Diversity is however not enough, the team members need to share the same excitement to the goal and willingness to help each other (Amabile, 1998).

Supervisory Encouragement

To create a sustainable passion and motivation most people need to feel that their work matter for someone. Therefore, it is important that management encourages its employees (Amabile, 1998).

Organizational Support

To truly enhance creativity in an organization, encouragement from supervisors is not enough. The entire organization must support it. It is the responsibility of the managers to create such procedures and systems and to make it clear that creative efforts are a top priority. Creative-supportive organizations consistently reward creativity, but avoid using money as a reward (Amabile, 1998).

2.4.2 Correct Information for a Task

According to Rubenowitz (2004), information can be divided into two main parts:

1. Information that is of instructive character, meaning that it is needed for a person in order to do their work in a satisfying manner and to make as rational decisions as possible.
2. Information of more general character connected to working conditions that can be interesting for the employees and that indirectly increase the working motivation, but that is not necessary for the work.

The importance of that the information should be relevant for the receiver of the information can not be denied. At many workplaces the staff experience a feeling of drowning in written information that they are not particularly interested in, and that not is looked upon as a resource that can be used as a tool to manage their own tasks in the best possible way. The overload of information can in this case be seen as an annoying stress factor (Rubenowitz, 2004). However, there are according to Rubenowitz (2004) ways to avoid this situation:

- An open communication between the superior and the subordinate. This gives the subordinate the possibility to ask questions. Open communication is generally a qualification/prerequisite to get relevant information.
- When it comes to the general information management can systematically try to delete/screen the information flow in order to give directed/addressed information that is adapted to different groups of employees and departments different needs.
- The employees should be encouraged to lateral information channels.
- Finally it is possible with IT to, in an as big extent as possible, facilitate the localization and the selection of wanted information.

2.4.3 Group Dynamics

When group work is functioning well it is easier for each individual to think and act independently. When it comes to group dynamics there are things to consider in order to make it work well. One thing is that a group should be given a high degree of freedom for its internal work to find the methods and the ways of working that suits the group best. Another factor is to give the group its own responsibility to divide the working tasks among the members. Further the group members should together take responsibility for that rotation systems are created to educate their own members in all different working tasks (Rubenowitz, 2004).

2.4.4 Leadership

On average a forth of the profitability in a company, even though this number varies a lot, can be connected to the leadership. It is therefore of vital importance, both for the organization and the employees, that the leadership is working in an appropriate

manner(Rubenowitz, 2004).

There is a difference between being a boss and a leader. Being a manager is the formal job title while a leader has the ability to optimize available resources in order to make the employees perform well within the frame of the organization. A boss gets its power from head decision makers while a leader gets its support from the employees. The leader has its power on personal characteristics and behaviour. Typical characteristics of a leader are a positive view of man, a social maternity, intelligence, motivation and confidence in the employees (Rubenowitz, 2004).

2.4.5 Mapping the Need of Education

To educate and develop the skills of employees in companies is desirable, necessary and today also generally accepted. However there can sometimes be an overconfidence of the positive aspects of education. The goal with the education is to increase the work-related competence/skills for each individual. However, a pitfall to look up for is training that is too general or touches upon areas those are not related to the participants current or future work (error distribution). Rubenowitz (2004) gives advice on how to perform the training requirement analysis:

- Have consultation with the concerned co-workers and responsible leader
- Perform a survey that can give direct or indirect information about the needs of training
- Analyse critical events those are pointing on gaps in education
- It is also important that there is someone in the organization who has the administrative responsibility. That person should be well grounded in the training requirement analysis.

3

Method

The method chapter describes the research strategy, the research approach and the methodological choices for the thesis. Further ethical considerations are elaborated on as well as the reliability and validity for the research.

3.1 Research Strategy

Bryman and Bell (2011) define the research strategy as the general orientation to conduct a research. They also argue that research strategy is distinguished between qualitative and quantitative research. There are fundamental differences between these two approaches in terms of principal orientation, epistemological orientation and ontological orientation (Bryman & Bell, 2011).

The quantitative research strategy focus on numbers and collection of a lot of data, such as questionnaires those can be sent out to many people. A qualitative strategy is focusing more on the words and the point of view of the participants (Bryman & Bell, 2011).

Table 3.1 shows the distinction between a quantitative and a qualitative research strategy, as illustrated by Bryman and Bell (2011, p. 16).

Table 3.1: Distinction between a quantitative and a qualitative research strategy

	Quantitative	Qualitative
Principal orientation to the role of theory in relation to the research	Deductive; testing of theory	Inductive; generation of theory
Epistemological orientation	Natural science model, in particular positivism	Interpretivism
Ontological orientation	Objectivism	Constructionism

This study is focusing on analyzing the problem solving and root cause analysis at GKN. It is a processes where there is no right or wrong nor a possibility to stand completely objective. Thus, the qualitative strategy is more suitable for this research since its purpose is to generate new theory. However, data will be collected both of qualitative and quantitative nature.

3.2 Research Approach

There are three major approaches that researchers choose between when conducting a research, inductive approach, deductive approach and the abductive approach.

The inductive approach generates new theory of the collected data from a defined topic and initial studied literature. The deductive approach focuses on defining a hypothesis and then finding evidence to either prove it or reject it (Bryman & Bell, 2011).

The abductive approach on the other hand allows a researcher to evolve the theoretical framework, empirical fieldwork, and a case study simultaneously (Dubois & Gadde, 2002). Dubois and Gadde (2002) discuss the use of the abductive approach as a systematic combination of two processes; the evolution of theory with empirical findings and to direct and redirect the study. This is an appropriate approach for a case study since it allows the researcher to take the opportunity to gain in-depth insights on areas unknown from the start. Figure 3.1 illustrates the framework of Systematic Combining outlined by Dubois and Gadde (2002).

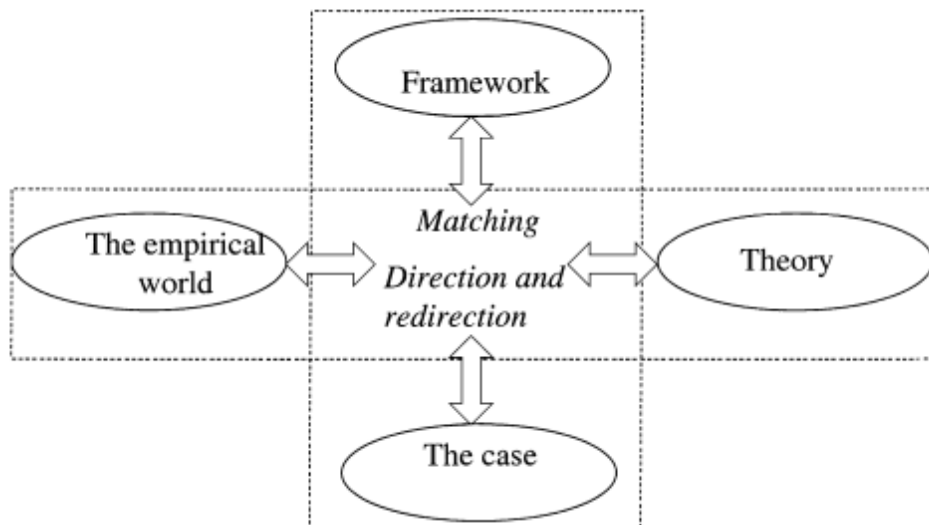


Figure 3.1: Framework systematic combining

Source: Dubois and Gadde (2002)

3.3 Research Design

The research design specifies the framework that is used to collect and analyze data to guide the researcher to choose and execute methods (Bryman & Bell, 2011). Bryman and Bell (2011) further argue that what distinguishes a case study from other research is: *"the focus on a bounded situation or system, an entity with a purpose"*

and functioning parts" (p. 60).

The research design of this thesis is a case study, performed at GKN Aerospace. The case study consists the benefit of analyzing a company in depth to get new insights. The research was of an exploratory nature, where the researchers explored to find areas to focus on.

The planned research design was to investigate the problem solving process in general and to find potential improvement areas. This to initially collect internal documents, historical data from the IT-system. Thereafter a literature study was to be performed. The information then was planned to lay the foundation for the research questions. Thereafter observations were supposed to be made in the manufacturing, followed by interviews of employees who were working with problem solving. In addition to the interviews, a survey was planned to get quantitative data to support the qualitative data from the interviews. Later, literature was planned to be performed and an analysis based on the results with the theory generated throughout the thesis. The methods and types of data are presented in Table 3.2

Table 3.2: Data structure on data collection methods

Data Collection Method	Primary Data	Secondary Data
Observation	Qualitative	
Interviews	Qualitative	
Survey	Qualitative & Quantitative	
Review internal documents		Qualitative

3.4 Research Process

The research process describes the actual research process which is different from the research design that was the initial plan. Since the research was done using an abductive approach the research process and research design differed.

Initially the research focused on the entire problem solving process in manufacturing and the research design was followed through all the methods. However, the scope took a different direction during the analysis of the data with new generated theory. Instead of focusing on the whole problem solving process the the scope was focused towards the root cause analysis and the previous steps in the process. Most of the results were however still useful for the analysis and discussion. The change of research questions and the direction lead to a focused analysis on root cause analysis.

3.5 Literature Study

The literature study was conducted continuously throughout the research process. Initially, literature was studied to get a broad view of theory related to Problem

Solving Processes and to study the problem solving methods used at GKN in more depth. Later, when the authors gained more insights, focus was set on theory where there was room for GKN to improve.

The literature study was conducted according to the five-step method, described by Bryman and Bell (2011). Notes were developed during the reading, potentially useful references were noted and keywords related to the research questions were then generated. Examples of potential keywords were: "Problem Solving Process", "Problem Solving", "Root Cause Analysis", "Group Dynamics", "Practical Problem Solving" and "Motivation". Literature was accessed through electronic databases, such as the Chalmers library database where a vast number of journals, books and other publications are available. Some references were also recommended by the supervisors at Chalmers University of Technology and GKN Aerospace. Further GKN's internal Operational Management System (OMS), where the company's processes are described as well as the Aerospace Standard AS9100 and AS13000, were looked upon.

3.6 Data Collection

3.6.1 Observation

Observation is a method where the observer watch and listen to others. A positive aspect of observation is that it is performed directly, unlike in a survey where the respondents describe how they work and feel etc. It is useful to take notes while observing in order to remember the situation more in detail (Bryman & Bell, 2011).

In this study the researchers went to the manufacturing and observed the daily work for Operators and Production Engineers. Information boards at the different value streams were studied to get a better understanding of the visual management of problem solving in manufacturing.

3.6.2 Interviews

There are different structures to choose from when performing interviews: structured, semi-structured and unstructured interviews (Bryman & Bell, 2011). When choosing the most suitable structure, the type of research, whether it is qualitative, quantitative, or mixed, needs to be considered. The differences lie mainly in the flexibility in asking and responding to the questions. In qualitative research the need for flexibility is greater and it is more important to capture the interviewees' point of view with rich detailed information, rather than obtaining standardized and directly comparable answers. In quantitative research there is a bigger need for standardization, in order to codify, process, compare and analyze the answers, and to prove reliability and validity.

For the purpose of this research, unstructured and semi-structured interviews were the most suitable. Since the previous knowledge of the authors initially were limited, the unstructured interviews helped to get a broad picture of the situation. The

semi-structured interviews were used later in the research to get answers on more specific questions, but they were still enabled the benefit of going of tangent, to drive interesting information from the interviewee that was not previously defined in the interview guide.

Interviews were performed with a variety of employees on different levels in the hierarchy to get information about how the Problem Solving Process works today, how problems are addressed and solved, and how the prerequisites are to work with in terms of effectiveness and efficiency with problem solving. The interview sheet was updated continuously and adapted to the interviewee to get the most out of every interview. The interviews were all scheduled for one hour and the actual time varied +/- 10 minutes. (To see an interview sheet used to interview Production Engineers take a look in the Appendix A.1.) The interviews were in almost all cases recorded. The authors both took notes and asked questions. When needed the authors used the benefit of the semi-structured interview to ask questions which were not in the interview sheet. After each interview the authors discussed it and collected all the notes from it in a common document to be used as a foundation for the empirical findings. The semi-structured interviews are outlined below in Table 3.3.

Table 3.3: Semi-structured interviews for the case study

Department	Position
Quality	Quality Manager
Engineering	Robust Design Engineer
Production	Manager Manufacturing & Quality Engineering
Production	Product Engineer
Production	Team Leader / Operator
Quality	Production Quality Engineer
Quality	Production Quality Engineer
Production	Product Engineer
Production	Product Engineer

3.6.3 Survey

In a survey, also known as self-competition questionnaire, respondents answer questions by completing a questionnaire by themselves (Bryman & Bell, 2011). The respondents receive an e-mail, a psychical paper, or a link to the digital questionnaire and completes it. It can contain open questions, closed questions or a combination of both. The open questions are faster to answer and easier to codify and thus easier to analyze, containing alternatives that the respondents chose from. The closed questions give room for the respondent to elaborate with their own words. There is a difficult balance for the creator of the questionnaire, to find between open and closed questions; to get data that can be quantified and at the same time get the respondents own words on topics. There is no right or wrong of how many open or closed question one should use, but the more open questions in combination with

a number of respondents, the more time consuming of the results the analyzes will be.

A survey gains some advantages compared to an interview: It is easier to administer, less time consuming, it allows the respondents to take their time to answer questions and it has the absence of affecting to respondent from the interviewer. There are however some disadvantages to consider as well such as not being able to help the respondent if they have difficulties filling it out. Also the respondents are limited to elaborate on the answers and the respondents are commonly anonymous.

Since the respondent answer the questionnaire themselves it lies in their perception of the question how they will answer. A way to avoid that respondents perceive questions differently is to before sending out the survey perform a pilot questionnaire for a few people of the thought sample. Thereafter, the creators of the questionnaire can make changes to improve the questionnaire.

Things to considered when performing a survey is the size of the population and the sample in order to get the right people involved and to get a reasonable amount of people answering that reflects the opinion of the population. The questionnaire should also be short in order to keep the respondents interested get a good enough response rate.

The survey for this thesis was performed internally at GKN to get data of how the problem solving and root cause analysis works. By using a survey a lot of quantitative data could be gathered which helped to get a broader idea of the processes and to identify improvement areas. The authors took into consideration the fact that it is of vital importance that the questionnaire is easy to follow in order to avoid misunderstandings for the respondents. Otherwise unusable data will be gathered since the respondents are unable to ask questions of how to answer it. All these aspects were considered when creating the survey for this thesis. It was also tested before it was sent out to two Production Engineers before sending it out.

The targeted respondents for the survey were Operators and Production Engineers from different value streams because they are the employees closest to the problem solving and they work with it daily. To get access to the Operators and Production Engineers, the managers of the value streams Disc, Fabrications, LPT/Spool, Structures and Special Products were emailed to delegate the survey and allow them time to answer. In the email the time limit and purpose of the survey was presented. The survey was available through the intranet where a direct link was provided in the email. The survey was available initially for one week. The time limit was selected to not be too far away in time to avoid it to fall between two stools. The survey had 17 responses after one week. Thereafter the managers were reminded of the survey and the time was stretched for another week. After the second week, the survey got a total of 30 responses from the six value streams. All the results can be found in Appendix A.3, a few selected figures are presented in the empirical findings. The distribution of the respondents is presented in Figure 3.2. The survey questions is available in Appendix A.2.

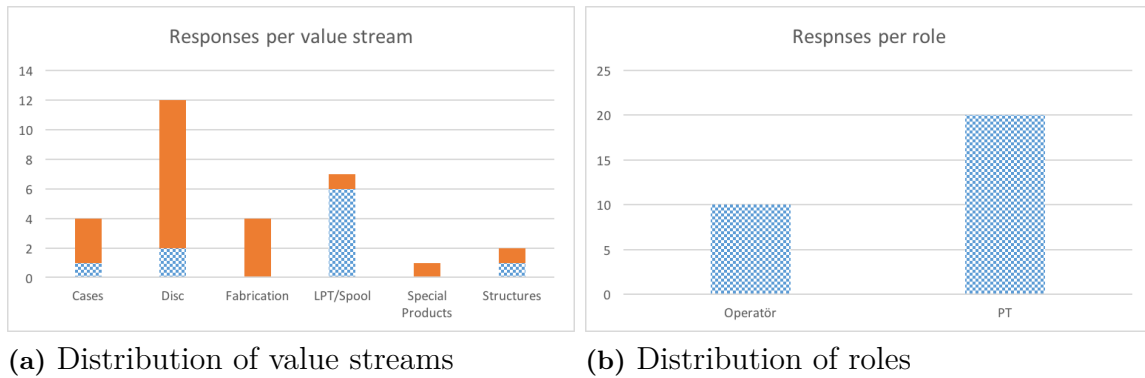


Figure 3.2: Survey distribution

3.6.4 Review Internal Documents

Companies and organization possess in general a vast number of documents those can generate valuable insights for a researcher. The documents can be for example description of processes, maps of the organizational structure, presentation documents, role description, organizational history etc. In this thesis, emphasis for the review on internal documents lied on reviewing the problem solving process and the used tools for root cause analysis, and to find relevant employees to interview.

3.6.5 Collect Historical Data

Historical data can also bring insights by just reviewing it or creating new analyzes. Historical data can be sales data, data of delivery, performance measurements etc. The data can be both qualitative or quantitative.

In this thesis, non-conformance data, and old PPLs were analyzed. The non-conformance data was retrieved from SAP and was used to analyze non-conformance characterization coding. The PPLs were analyzed to see how the method was used to solve problems.

3.7 Ethical Considerations

There are a number of ethical issues to consider while performing data collection. In this thesis, ethical considerations were mainly related to the interviews and the survey. The ethical considerations in this master's thesis were informed consent, invasion of privacy, harm and deception.

Informed consent

All interviewees were notified about the purpose of the interviews and how they could access the results from the interview. The interviews were all scheduled for an hour.

Invasion of privacy

The majority of the interviews were recorded, which was accepted by the interviewees pro the interview. All of the interviewees were kept anonymous throughout the report. The authors thought that the anonymity would make the interviewees give information that they otherwise had not given if their names were published.

Harm

The authors considered this research unlikely to harm any of the participants, nobody of them are mentioned in a negative way. Still confidentiality was maintained as well as anonymity.

Deception

The research was presented for the interviewees and survey respondents as a thesis work connected to the problem solving at GKN, described in a bit more depth. This was done to get the trust of the participants and to be loyal.

3.8 Reliability and Validity

3.8.1 External Reliability

External reliability means to what degree research can be replicated. For a qualitative study this can be tricky since it is not possible to freeze setting that is social. What a researcher in that case needs to do is adopting to a social role that is similar to the original researchers one. (Bryman & Bell, 2011)

Since this research is of qualitative nature the result could have been affected by the authors background and knowledge historically. One of the authors had performed a Six Sigma project at the company and had further worked there half a year. This lead to that that researcher already had connections to some of the employees at GKN. This facilitated the possibility to get in contact with the right people for this specific thesis in order to get interviews and other kind of data. For another researcher, without connections within the company, managing to replicate this research could be difficult in this respect, at least managing with the same time frame.(Bryman & Bell, 2011)

3.8.2 Internal Reliability

Internal reliability concerns in situations for research when there is more than one observer to which extent they agree about what they hear and see. In this thesis there where two writers conducting the research. Discussions came up and the writers had different views on things occasionally, but in all the deal breakers for the thesis the writers were on the same page. This facilitated the writing process.(Bryman & Bell, 2011)

3.8.3 Internal Validity

If there is a suitable match between the researchers observations and their theoretical ideas which they develop is the explanation of the concept Internal Validity. It is positive if the study has been performed over some time in qualitative research since it gives the researchers a possibility to make sure that there is a level that is high of congruence between the observations and concepts. (Bryman & Bell, 2011)

Positive for this study was that its time span was a whole semester so that the researchers really got into the "GKN world" properly and had time to build up some relationships with employees with which they could recap continuously about the problem solving.(Bryman & Bell, 2011)

3.8.4 External Validity

External validity concerns to which degree that findings ban be generalized through a social setting.(Bryman & Bell, 2011)

4

Empirical Findings

The findings in this thesis are based on the results from a number of interviews, a survey, observations in the production facilities, research of the intranet, internal documents, historical data and GKNs ERP-System SAP.

4.1 GKN Standardization for Non-conformances

GKN has its own standard for non-conformances and problems, which starts with a Q followed by a number. The most common used once are Q1, Q2, Q3 and Q4.

Q1 is also called an Escape. Described more in detail a Q1 is a non-conformance that was identified by the customer. Since customer complaints interfere with customer satisfaction Q1s to always have a very high priority. A Q2 is a non-conformance identified by GKN where the supplier delivered material that did not meet the requirements. The Q3 is an internal non-conformance where a non-conformance has been identified in the manufacturing, often caused in the production. Finally a Q4 is a remaining non-conformance, a Q3 that has not been solved internally, and the product later has been delivered to the customer with the non-conformance still remaining. In these cases GKN has informed them about the non-conformances on the products and the customers have accepted them.

4.2 The Problem Solving Process According to OMS

The Problem Solving Process, or the process of non-conformances is described in GKN's intranet in the Operational Management System, most commonly known as OMS (GKN Aerospace, 2016a). The Problem Solving Process at GKN is outlined in Figure 4.1.

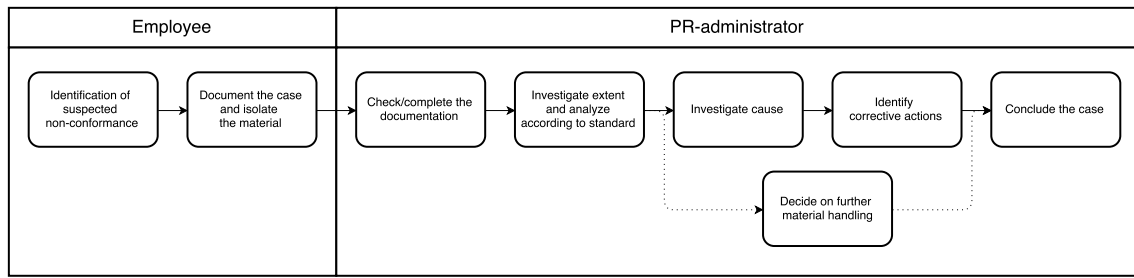


Figure 4.1: Non-Conformance process flow

The list below describes the steps in Problem Solving Process as was illustrated in Figure 4.1.

1. Identification of a suspected non-conformance

The first step is the identification of a suspected non-conformance, this can be performed by any employee but is usually an Operator.

2. Document the case and isolate the material

The second step is for the employee to document the suspected non-conformance by creating a report in the IT-system for non-conformances. The report is called PR-report, Q3 report is most used at GKN and will be used continuously in the thesis. Another purpose of this step is to isolate the material for further use until an investigation is complete.

A list of fields that must be completed when the report is created:

- Order number
- Operation
- Material Number
- Description
- Version
- Serial Number
- Department Responsible
- Plant for Material
- Ref Qty
- Description
- Error description
- Sequence of events

3. Check/complete the documentation

The third step is for a PR-administrator to validate the information reported by the employee in the previous step and to fill the gaps that are necessary to both determine what to do with the hardware, where the suspected non-conformance was detected, and to continue the problem solving.

4. Investigate the extent and analyze according to standard

Forth, the PR-administrator investigates the extent of the suspected non-conformance and verifies it according to standard.

The suspected non-conformance must be correctly analyzed according to current standards which applies both to the material or process and the results must later be documented in the PR report in SAP.

The PR administrator must when necessary seek expert help from other sources so that the design, quality, material and technical production aspects are met. Examples of experts could be method owners, designers, engine technicians and engineers etc. In cases where a PR manager is unsure of what experts are needed for a correct decision a Material quality engineer is contacted for a joint assessment.

5. Investigate cause

The fifth step is to investigate the cause of a problem; breaking down causes to the lowest possible level to ease the identification of corrective actions. Knowledge about the process is important in this step and to, when in need, contact experts to identify the cause. Examples of experts given are Operators, constructors, material experts, motor engineers, motor technicians etc. If the non-conformance is residual the root cause and problem solving should be documented. Suggested tools for finding the root cause are Tree diagram and Fishbone diagram. There are regulations for some products with requirements of the root cause analysis.

6. Identify corrective actions

The purpose of the sixth step is to identify corrective actions and appoint personnel responsible for the implementation in order to prevent future non-conformances of the same cause.

7. Decide on further material handling

A parallel step to investigate cause and corrective actions is to decide what to do with the affected material. There are several decisions for what to do with the material: Accept as it is, Keep it with a remaining non-conformance for further investigation, Scrap, Re-work or Reparation. These will not be elaborated on further since this is not a part of the problem solving.

8. Conclude the case

The purpose of the final step is to ensure that the case is concluded in a correct and traceable manner and that the necessary information has been passed to

all concerned.

4.3 Value Streams & Roles

The production at GKN is divided into value streams. The different value streams manufacture products with a great variety of size, parts, operations and complexity. The majority of the products are completely manufactured by one value stream. However, in some cases there are products that are completed by more than one value stream, so called shared products. Today the value streams work individually with problems when they arise. There are no processes for those products that are shared between value streams.

The value streams at GKN are Cases, Disc, LPT/Spool, Structures, Fabrication and Special Products. The different value streams have got boards where information is stated about new problems, status of ongoing problems, list of untreated problems, reoccurring problems etc. At their boards the value streams meet individually every morning and discuss information and issues they have.

There are different roles for the employees who work at GKN. There are Operators who work with manufacturing. Then there are Operators who have been given extra responsibility when it comes to problem solving, the Q-role. Not all value streams have Q-roles. There is also the PR role, Production Engineer, known as PT and Team leader. The Operators in the value streams are divided into teams of different operations.

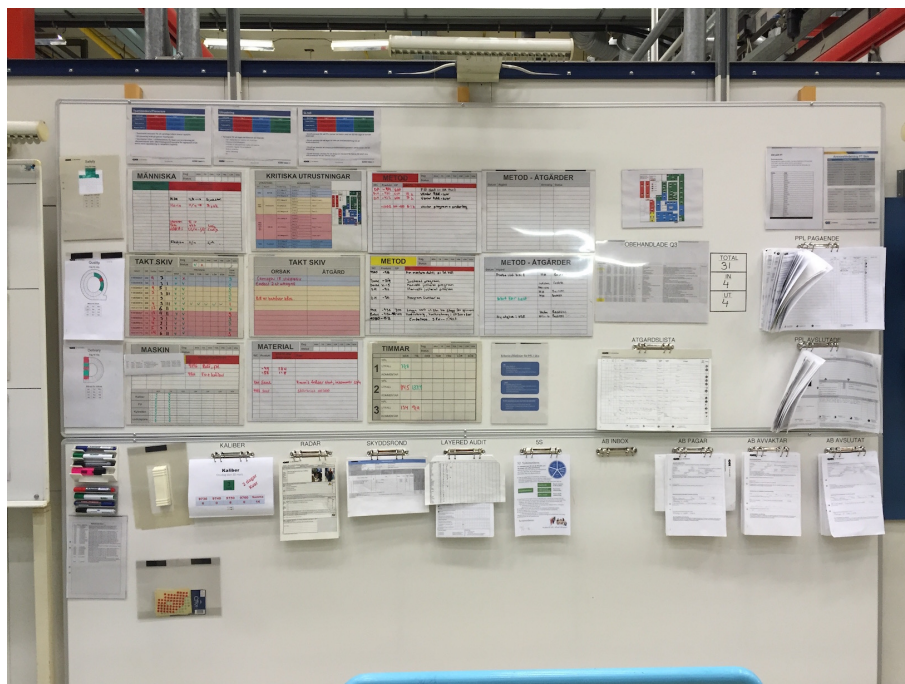


Figure 4.2: Board at the value stream Disc

Production Engineer

The Production Engineers divide the responsibility of the manufactured products. A Production Engineer should, when a non-conformance has been detected, as soon as possible evaluate if a product should be scrapped, if the product should be reworked, suggest if the product should be returned to the supplier or if repair should be made.

PR Administrator

The Production Engineers are responsible to drive the problem solving to find the root cause, identify and implement countermeasures when a non-conformance has been reported. When a Q3 is reported by an Operator, the assigned PR Administrator is emailed.

A PR Administrator needs to have, except from the PR-administrator education, one of the following educations; Root cause analysis, Glade Kocken - Problem Solving or Six Sigma (Green or Black Belt). The PR Administrator is in the most cases Production Engineer.

Q-Role

The Q-Role is an Operator with extended responsibilities for the quality in the manufacturing. The purpose of this role is to take some work load from the Production Engineers and improve the communication between Operators and Production Engineers. The role includes the responsibility to forward disturbances brought up on morning meetings to the production team, since not all Operators attend the meeting. The Q-Role has the authority to stop a product, a machine or an operation to investigate the cause for a reported Q3. The Q-role is responsible for creating a PPL when it is required, and to assure that the Q3 created by the team is correctly filled out. The Q-role will be educated to create a standard of the format of the Q3 when it leaves the team to the Production Engineers.

The Q-Role was introduced in 2015, and has only been used so far by the value stream Disc. According to interviews by both a Quality Production Engineer and Q-role operator the role is not functioning well enough at the moment. There is not enough time to do what is expected and the value streams are slow with incorporating the role.

4.4 Non-Conformance Reporting in the IT System

GKN use SAP to report and document non-conformances. See Figure 4.3 for an illustration of the reporting form.

4. Empirical Findings

The layout to create a Q3 report is illustrated in Figure 4.3 and is the view that the Operators see when they report a non-conformance. The Operators are suppose to fill in all the information in the tap "header". There are instructions on how to do it in the SAP menu. The fields cover the necessary information to isolate the material and describe the non-conformance.

Notification

Extras

Create Internal Non Conformance - Q3

Sören Knuts

Notification:

Status:

Header

Items

Info tasks

General Information

Order Number:

Operation:

Material Number:

Description:

Version:

Ref. Number:

Ref Notification:

Depart. Resp:

Vendor Batch:

Device Data:

Plant for Mat.: 0004 GKN Aerospace Swede

Notification Information

Complaint Qty:

Ref Qty:

Description:

Longtext:

Avvikelse mot Krav nr/Spec. nr:
Dimension/Defekt(typ + resultat + placering):
Orsakande WC:
Orsak/händelseförlopp:

Documents

Documents

Document Type

Document

Document Part

Doc. Version

Description

Status

The table does not contain any data

Attachments

File extension

Date created

Empl/appl.name

This note contains no attachments

Contact Persons

Author:

Coordinator:

Figure 4.3: Operator’s layout to create Q3 report

Figure 4.4 illustrates the interface for when a PR Administrator concludes a Q3. There the PR Administrator is able to enter the causing operation, root cause and corrective actions.

The screenshot shows the SAP 'Create Internal Non Conformance - Q3' interface. At the top, there's a header bar with 'Notification' and 'Extras' tabs, the title 'Create Internal Non Conformance - Q3', and the user 'Sören Knuts'. Below the header, there's a navigation bar with 'Header', 'Items', and 'Info tasks' tabs. The 'Items' tab is active, showing 'Item Number: 0001' and navigation buttons like 'Previous item' and 'Next item'. The main form is divided into several sections:

- Requirement Location:** Includes fields for 'Drawing Sheet', 'Location', 'Character No.', 'No of Defects' (set to 1), and a 'Serial / Batch No' button.
- Defect Type:** Includes fields for 'Code Group', 'Type', and a large 'Longtext' area.
- Causing Organization:** Includes fields for 'Code Group' and 'Cause Code'.
- Causing Process:** Includes fields for 'Code Group', 'Cause Code', and a 'Longtext' area.
- Root Cause:** Includes fields for 'Code Group', 'Cause Code', 'Causing Op', 'Causing WVC', and a 'Longtext' area. There's also a small table labeled 'Cause'.
- Corrective Action, Process:** Includes fields for 'Code Group', 'Task Code', 'Responsible', 'Status', and a 'Longtext' area. There's also a small table labeled 'Sort number' and a 'PI Finish' field.

Figure 4.4: PR Administrator's layout to update Q3 report

An experienced Production Engineer said that SAP is difficult to use when working with non-conformances. Operators say that it takes too much time to create a Q3 and that there are uncertainties of what they are required to fill in.

All data reported into the system is accessible to be used for analyses. The quality department follow and measure reoccurring non-conformances based on data reported in SAP. For defect type, root cause and corrective actions, standardized codes are available. The purpose of the codes is to enable easier monitoring.

Interesting when looking at the use of the codes for reported root causes, see Figure 4.5, is that almost all are reported with the same root cause. The majority of the Q3s are reported with the root cause of "Process capability was insufficient", which have the explanation: *"Poor manufacturability, selected production parameter or the*

manufacturing method is not suitable".

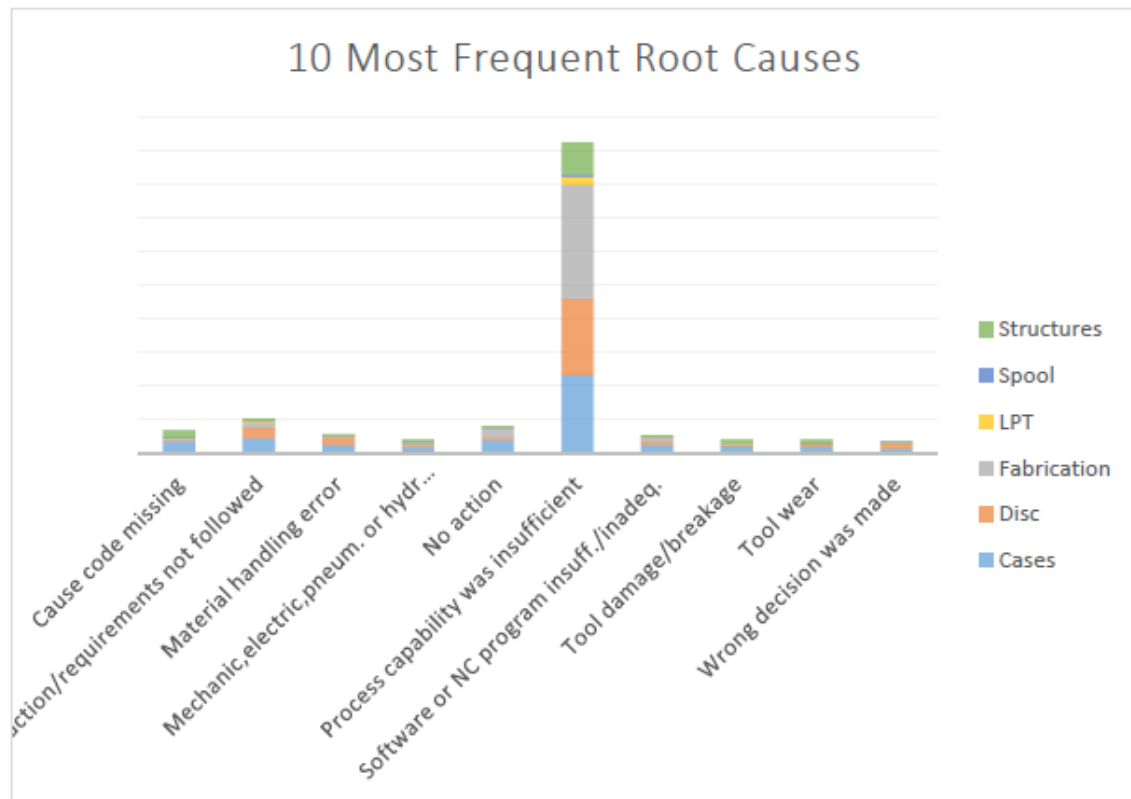


Figure 4.5: Figure of reported root cause codes

A new system, QSYS will be introduced in the near future to force Operators to create a Q3 report when they have measured a deviation from the requirement. Today they do not have to create a Q3 report even if they measure a deviation.

4.5 Problem Solving Tools

This sections covers the findings those are related to the method or tools used to identify the root cause, or more general problem solving tools where the root cause analysis is a step in the process.

4.5.1 PPL

PPL is a template developed by GKN that builds on Toyota's PPS (Liker & Franz, 2004), see Appendix A.9 for the template. PPL is an abbreviation for the Swedish "Praktisk Problemlösning" and is much more frequently used at GKN than 8D and Six Sigma. Here an A3 format is used. Two pages are used in landscape. The first page is divided into squares where six steps are performed. At first a *Description* of the problem is made where the sequence of the activities are described and where the problem occurred. The next step is to *Identify temporary arrangements*. This is

followed by *Identifying root cause/s of the problem*. The fifth step is to *Identify and plan activities* that will solve the problem. Finally the template has an *Evaluation square* of the result where standardization is included.

According to the guidelines a PPL should be performed when a product needs to be scrapped, when there is a remaining non-conformance (Q4), or if there is a reoccurring non-conformance. In the last case, an old PPL from the same cause might be re-used.

The Manager of Manufacturing & Quality Engineering for Disc and the Production Quality Engineers that were interviewed agree upon that the PPL is a good tool to follow-up of problems.

Occasionally PPLs are used for simple problems, but then only as a tool for documentation and follow-up. In these cases not all steps of the template are necessarily used. In some cases the root cause is already known, according to the interviewees. From the survey, almost a third of the respondents, 30 % say that the work with PPL or 8D works bad or very bad.

The PPL-template has been updated continuously with minor changes, the last version is the sixth. Previous versions are still available and used by some employees.

4.5.2 8D

Some customers require that GKN use 8D and so does the Aerospace Standard 13000 (AS13000) when reporting a non-conformance.

The 8D template has been complained about by someone in the organization in the survey on the open question "How could the work with problem solving be improved?". One Production Engineer described 8D as: "A poor tool. By some reason it should be used when non-conformances are sent to certain customers. [...] the PPL tool works."

4.5.3 Just Do It

Something that the authors found from the interviews is that it is important to distinguish between the degree of complexity in different problems. Some problems require a Problem Solving Process of a higher level where a template like PPL, 8D or even a Six Sigma project will be needed, while other problems only require a "Just do it" undertaking, according to a Production Quality Engineer. It is substantial to use the tactic that is suitable for the problem in order to be efficient. Sometimes there is no need for a thorough analysis of the root cause for issues that can be fixed straight ahead.

4.6 Problem Solving in Practice

This section covers the findings from the different steps in the problem solving and root cause analysis. The findings are primarily from interviews and the survey.

4.6.1 Describe the Problem

The description of the problem can be divided in to two phases. The first is when an employee report the non-conformance to the IT system, the Q3 is created, and the second is when the problem is described in the method/tool used to solve the problem, such as a PPL.

The lack of a good problem description is quiet common at GKN according to the majority of the interviewees with Quality Manager and Production Engineers, when asked what is the major problem when working with problem solving. It is rarely the same person that initially reported the problem that leads the problem solving, thus it is very important that the problem is described thoroughly from the beginning in the Q3, according to survey respondents. Worth mentioning is that the authors have seen well described problems as well which the organization can learn from.

4.6.1.1 Creation of a Q3 Report

What the authors have found from the interviews is that the Operators sometimes do not describe the non-conformance sufficiently. The problem description of a Q3 can sometimes be so poor that it is not possible to understand how and where the problem occurred. There is a gap in the understanding between the Operators and the Production Engineers of what is required and what is relevant to proceed in the problem solving. Worth mentioning however, is that some Operators do the Q3 reporting more than well.

Due to the lack of well created Q3 reports, a Production Engineer at the value stream Special Products created instructions about what information is required. They were sent out to the Operators at the particular value stream. The information is similar to what is described in Section 4.2.

Some value streams already have a pile of unmanaged Q3s to work on before dealing with the most recent one. The consequence of a poor Q3 report is that the root cause becomes harder to find and makes the problem almost unsolvable since sometimes too much time has passed since it occurred till it is on top of the pile. When it finally reaches the top of the pile, neither Operator nor Production Engineer understand or remember it, according to Production Engineers. At the value stream Disc for instance, they have a constant pile of unmanaged Q3 reports. There it can take up to three weeks to start working with a problem. A good habit commented on by a Production Engineer at the value stream Fabrication is to, if needed, when a non-conformance is reported, directly walk to the place of the problem to get vital missing information about the Q3 and fill out gaps. After that the problem can be managed when there is time.

4.6.1.2 Problem Description in the PPL

When working with a PPL, another finding made is that the problem description is said to be of vital importance for the identification of the root cause, however there are several examples that show gaps in the descriptions. The authors have seen examples with PPLs lacking headlines, containing only one sentence such as "Takten mot PT hålls inte tillräckligt bra" which can be translated to something like "The pace towards time plan is not good enough", or "Produktion X klarar i dagsläget inte av att hålla den takt som krävs för att vara på plan mot TP vid årsskiftet", translated to "Production X can today not manage to hold the pace that is needed to time plan at the year-end.". Pictures can help sometimes to visualize if a problem is difficult to describe. This opportunity is not used very often. Another vague problem description is illustrated in Figure 4.6.

Arbetsblad för Praktisk Problemlösning - PPL

Problem upptäckt av _____ Utfär _____
Kontrollant

1. Problembeskrivning

Beskriv problemet
Märke på bultplan på skiva _____

Var såg man problemet först?
Kontrollen

Problemnedbrytning
Hur uppstod problemet? När uppstod problemet? Beskriv händelseförloppet. Analysera/Vad hände i praktiken? Använd fakta, data, skisser/bilder. Undvik tyck och tro.

Figure 4.6: Vague problem description of a PPL

Even though many of the interviewees had a lot to say about the problems and the problem descriptions, 83 % of the respondents say that it works well or very well to describe and break down the problems in the survey. However, what is interesting is that 33 % of all the respondents say that the problem description is based rather on assumptions than on facts, among these 50 % of all the Operators.

4.6.2 Set a Target

According to an interviewed Robust Design Engineer, setting a target for the problem solving is very important since it helps to validate if a problem is solved. The

engineer emphasizes that the target needs to be reachable and possible to measure and follow up. Still, a lot of the PPLs that have been reviewed miss this information.

More than one third of the respondents, 37 %, from the survey say that it works bad or very bad to set targets for the problem solving. The distribution is equal for both Operators and Production Engineers.

4.6.3 Identify and Implement Containment Actions

In the past the most prioritized task in the manufacturing has been to get the products ready for delivery with all requirements approved. Nowadays, proactive quality work is considered more, but the culture still contains too much fire fighting.

In the survey, the Operators have a different opinion regarding how well it works to identify and implement containment actions compared to Production Engineers. The majority of the Operators say it works bad or very bad (60 %), and the majority of the Production Engineers say it works well or very well (75 %).

4.6.4 Analyze the Root cause

In manufacturing the most common tool used to analyze and identify the root cause is by far the 5 Why, and it is incorporated into the back of the PPL template. At occasions the Fishbone diagram has been used.

The 5 Why is used in different ways at GKN, depending who is working with it. The level of how much the cause is broken down varies a lot; sometimes there is only one why asked, and often not more than two to four, even though it occasionally happens that five are asked. The 5 Why blocks in the PPL template are rarely well explained. Often there are short explanations. The identified root causes are often written so that only people who were participating when the 5 Why was performed can understand it. It is debatable if someone would understand a month later. In many cases the root causes seem to be able to be broken down even further, thus one can not help but wonder if the true root cause was identified. There are often a number of identified root causes for a problem. See Appendix A.4 for the 5 Why analysis template that is attached in the template. Despite the observations above the majority (80 %) of the respondents seem to agree that it works well or very well to identify the root causes to problems.

4.6.5 Develop Countermeasures

The interviewed Robust Design Engineer who has a lot of experience of problem solving and who has participated in many PPLs has seen a tendency that people focus on developing lists of corrective actions and executes them. The corrective actions are not always a countermeasure for the root cause. An interviewed Production Engineer and Operator from the value stream Disc said that the list of countermeasures on the PPL sometimes can include other actions which do not concern the root

cause. At Disc however they also have another way for managing general improvement actions, a list made specifically for general improvements. These are however not clearly separated.

There is gap between the roles on how they agree on the work with developing countermeasures; 50 % of the Operators say it works bad or very bad and 80 % of the Production Engineers say it works well or very well.

4.6.6 Implement Countermeasures

According to both the interviewed Quality Manager and Manager Manufacturing there is an inertia to implement countermeasures. There are several reasons for why it takes a lot of time to take actions and implement these. First, there are several countermeasures in circulation. To avoid that a non-conformance occur again, actions are taken which are time consuming. In addition, the countermeasures are often complex to implement, especially related to the manufacturing.

The manufacturing is controlled and specified. All operations are defined in detail, what tools to use, how to control and measure, what material etc. Thus, even the simplest change in the method requires a new release of an operation list, which first needs to be approved by the customer. The process of changing a list is in itself quiet complex according to the Production Engineers. For Operators the wait for a new release of the operation list can be frustrating since they cannot use better tools, methods, materials etc. to avoid a non-conformance before the new edition. Further, Operators mention that planned and accepted countermeasures are not communicated well and it is not transparent when they are being implemented. They request to know better if other implementations are prioritized and when editions are planned to be released to reduce frustration.

In the survey, both the Operators and Production Engineers answer fairly equal about implementing countermeasures; 53 % say it works well and 46 % say it works bad.

4.6.7 Follow-up and Standardize

Follow-up is a very important step of the Problem Solving Process to validate that the true root cause was identified and that the countermeasures solved the problem. For instance, the value stream Disc emphasizes on the importance of the follow-up step at the morning meetings and when working with PPL. When interviewing a Production Engineer from the value stream Structures, they are not working as good with following up countermeasures to validate that the root cause was identified as they can. When looking at PPLs on the fabrication's board, the follow-up step on those hanging there where not filled out. Based on the survey, 43 % of all the respondents, or 60 % of the Operators do not agree or do not agree at all that the countermeasures are followed up after implementation. 57 % of the respondents do not agree or do not agree at all that the countermeasures are standardized in the

production.

4.7 Prerequisites for Problem Solving

4.7.1 Team

From many of the interviews the interviewees stress the importance of having a good team when identifying the root cause. Characteristics of a good team they described were a broad competence, people close to the problem, people participating voluntarily and knowledge of the method.

Sufficient required knowledge is a factor the respondents from the survey say is missing (23 %) to some extent in the team that work with problem solving and root cause analysis. A successful problem solving according to the interviewees includes also having a great leader, which 83 % of the respondents of the survey agrees with. However, an influential factor to manage to gather the right team is to have the right connections with people within the organization. The biggest issue with gathering a team with the right knowledge is that it can take time according to some interviewees and that it is difficult to find the right people when you do not have a lot of connections.

Having a group dynamic that works well is something that 30 % of the Operators do not feel they have, see Figure 4.7. On the other hand, 35 % of the Production Engineers say that they totally agree that the group dynamics works well, none of the Operators agree to this. Thus, there is a difference in the perception of the group dynamics depending of the role in problem solving at the company.

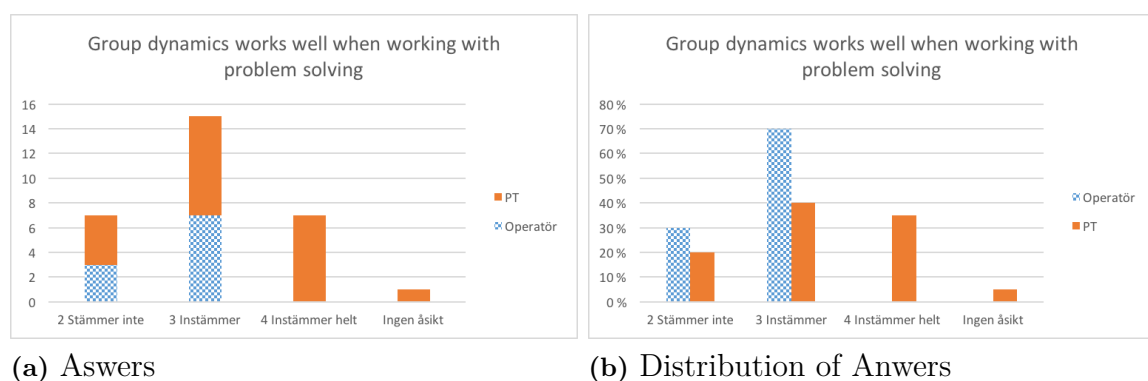


Figure 4.7: Communication between Operators and Production Engineers

Regarding the number of team members, 80 % are satisfied. Nobody says that there are too many participants when working to identify the root cause. The most common number of team members are three or four. However, 17 % say that there in general are too few people working with a problem.

4.7.2 Managerial Control

A finding from an interview by a Production Engineer, from the value stream Structures, is that the Operators primarily are controlled on delivery, rather than quality work. There are clear requirements of what, when and how many hardware the Operators are supposed to deliver, however, quality work is not rewarded in their daily work. There are no incentives for the Operators to take time from their production time to work with problem solving. One third of the respondents from the survey (27 %) say that meetings regarding problem solving often are canceled.

4.7.3 Communication

Operators, Production Engineers and Production Quality Engineers all agree that there exists a certain "we and them" culture between Operators and Production Engineers. Operators say that the Production Engineers do not visit the production often enough and that they do not even always visit hardware when there is a deviation. Almost a third of the respondents from the survey (30 %) say that the hardware is not visited when there is an deviation.

The Operators say that they are not always told when a deviation has been discovered that appeared at their operation. For example: a controller in a later process step measures a requirement and observes a deviation. Then the controller brings this information to the Production Engineers, but does not inform the previous steps of the issue. Based on the survey, every other Operator (50 %) do not think that they are informed when a non-conformance has occurred. Further, an answer of an open question in the survey written by an Operator said: "The Operators in concern are not always invited to participate". The Operators also say that they are not being informed when a countermeasure is to be implemented.

There is a gap between the Operators and Engineers on how they perceive how well the communication works. Two thirds of the Operators (63 %) do not agree that it works well and only one fifth of the Production Engineers say the same, see Figure 4.8.

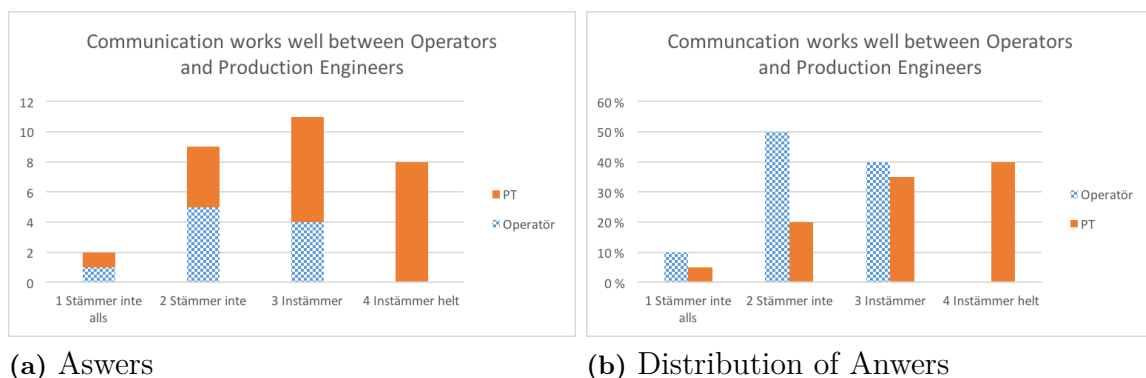


Figure 4.8: Communication problem between Operators and Production Engineers

4.7.4 Resources for Problem Solving

There are two areas that are repeatedly discussed when it comes to resources: there is not sufficient time for Production Engineers when working with problem solving and the issue of Operators not having designated time to report problems.

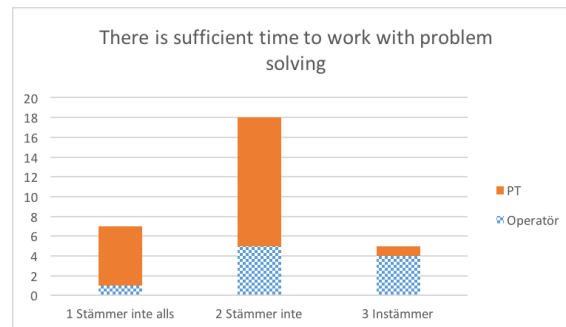


Figure 4.9: Not sufficient time for problem solving

The value stream has a constant pile of unmanaged Q3 reports to solve. There is not enough time or resources to reduce the pile. In the survey 19 of 20 Operators say that they do not agree or do not agree at all that there is enough time to work with problem solving, see Figure 4.9. On the open ended question in the survey: "How can the work with problem solving be improved?", three people wrote specifically that more time should be devoted.

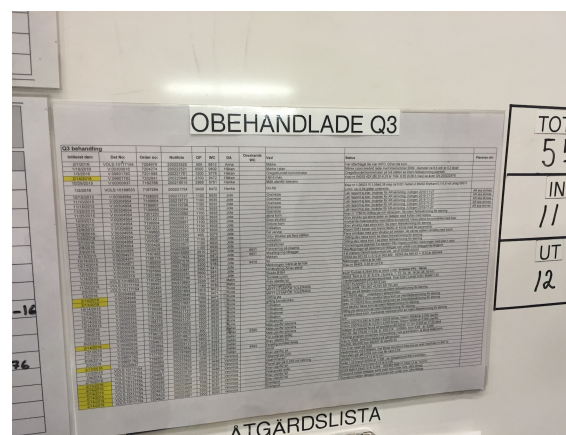


Figure 4.10: The level of unmanaged Q3 remains high

The second issue of resources is that the Operators do not have any designated time to report Q3s and yet it is expected of them to make a complete and detailed report. According to a Production Engineer the Operators say that it takes a lot of time to fill out a Q3 report. The time the Operators take to work with reporting non-conformances and other problem solving work takes time from their production work, and they are suppose to produce. Producing is the number one priority. An interviewed Operator with the role Team leader and Q-role even said that the time is inadequate and that they are suppose to have designated time to problem solving, but that it does not fit their production schedule.

4.7.5 Motivation to Solve Problems

Both Operators and Production Engineers have the motivation to work with problems. Almost everyone agrees or totally agrees about that they feel motivated to both report problems (87 %) and to work with problem solving (93 %). This is also supported by an interviewed Production Quality Engineer who said that there is nothing wrong with the motivation and the will to solve problems at GKN.

4.7.6 Problem Solving Education

According to the survey 80 % of the Operators say that there is not enough education regarding problem solving: 25 % of the Production Engineers say the same, see Figure 4.11. Only one Operator say that there is enough education. 75 % of the Production Engineers agrees or fully agree that there is enough education for problem solving. There is a difference in perception of the two groups.

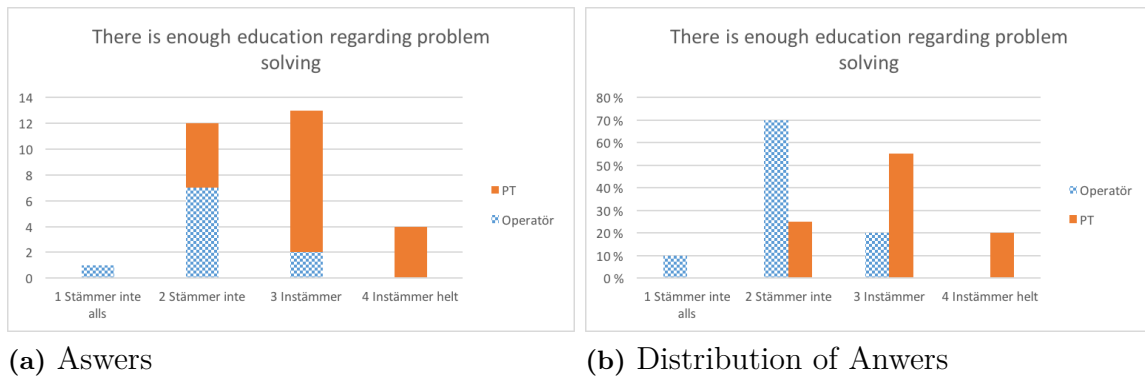


Figure 4.11: Operators dissatisfied of available education

5

Analysis

The analysis focus on the root cause analysis and the former steps. The figure shows the following step in the process to eliminate the root cause, but it is not a part of the analysis.

Empirical findings show that the prerequisites to find the root cause of problems at GKN can be improved. The root cause analysis is of great importance since it helps to evaluate the relationship between the cause and the effect of a problem and since it avoids that a problem re-occurs (Sondalini, 2016). When the cause of a situation is unclear it becomes difficult to to solve the problem and this is problematic for GKN. The steps in the problem solving before and after the root cause analysis are illustrated in Figure 5.1 below.

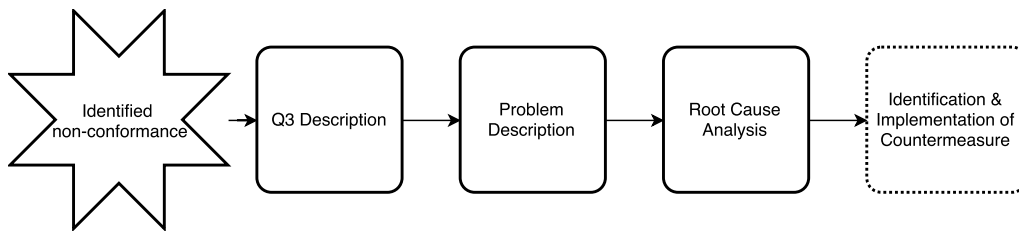


Figure 5.1: Steps in the process of finding the root cause

Figure 5.2 illustrates what is beneath the surface of the reoccurring non-conformances. What first is visible is the use of the methods, how the descriptions and root cause analysis are poorly performed. By digging deeper there are a number of factors that can explain the issues of poorly used methods.

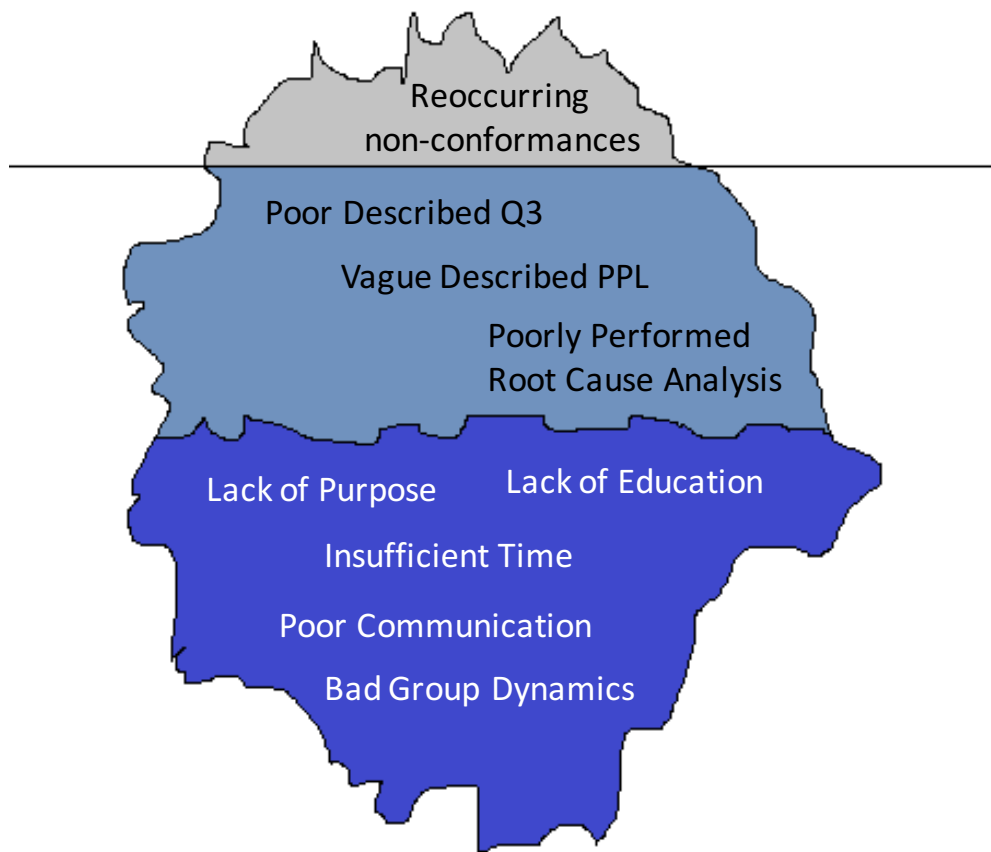


Figure 5.2: Beneath the surface of non-conformances

5.1 Sometimes Problems Reoccur

The most obvious way of discovering that the root cause of a problem has not been found, is if a problem reoccurs. This happens occasionally at GKN. When a problem reoccurs it causes frustration for the employees and it leads to waste such as scrap, rework or repairing, which is costly. The time and money it takes to do a proper root cause analysis is cheap compared to having problems returning.

5.2 Occasionally only Symptoms are Solved

The road from identifying a problem to stopping it from reoccurring starts with the identification of the problem and the reporting. If the process from the beginning to the end is not done properly there might be a risk that only visible symptoms are solved and not the underlying root cause, which can result in recurrences, see Figure 5.3 for an illustration of solving symptoms. Taking more time to make a proper work from the beginning saves time from having to search for information, get new information because it is lost, fix reoccurring material because the root cause was not adjusted initially etc. 95 % of the Production Engineers say that there is not enough time to work with problem solving. There is no empirical evidence of that

being the main reason for reoccurring problems, but it can have an effect.



Figure 5.3: Consequence of only solving symptoms

Source: Hammersberg (2015)

5.2.1 Vague Q3 Reporting can Affect the Problem Solving

The Q3 reports are not always being filled out properly. There are several reasons for this. As mentioned the Q3 report lays the foundation of the result of the problem solving and the identification of the root cause. A detailed Q3 report can save a lot of time in the process of solving the problem.

One reason for why the Q3 reports are poorly described sometimes is that the Operators do not understand the purpose of performing a Q3 report in detail. Also, filling out a Q3 takes time from the manufacturing work for the Operators. This whole situation puts a mark on the following work of solving a problem.

What the authors have seen, both from the survey and interviews, is that there is no assigned time for quality work for the Operators. Thus, when the Operators fill in a Q3, it takes time from their planned manufacturing time. The authors suggest that the Operators are given the time they need to report the non-conformance properly.

In the Q3 reporting the descriptions of what happened are sometimes not clear. When this happens a Production Engineer has to go down to the production to search for required information about the problem since it otherwise is difficult to understand what the problem was. When the Production Engineer has to interrupt the Operators in their work in search of information it can cause stress and frustration among both engineers and Operators. The Operators usually have information about the Q3 reports, however information tends to get missing with time. If too much time has passed Operators can forget what happened, which sometimes has been the case. This makes a problem harder to solve. It also makes the time it takes to solve the problem longer and then other problems are put in a pile and have to wait. This increases the risk that problems reoccur.

According to Bergman and Klefsjö (2010); Åhlström (1997) everyone should be committed and responsible for quality work. A responsibility for the Operators is to be allowed to stop the line, the operation or the machine if they find defective parts (Shingo, 1981). Bergman and Klefsjö (2010) also emphasizes that a corner stone of quality is to be focused on, not only the external customers, but the internal, where the Operators have a big role.

5.2.2 There is Room for Improvements of the Problem Descriptions

As described in the results the problem descriptions in the PPLs are sometimes vague. There is a feeling of rushing for solutions and actions instead of taking time to the planning phase. This may cause that the wrong problem is solved and that the employees do not get a clear understanding of what the problem was. This could be a cause of that not enough time is spent on writing the problem description enough in detail.

A poor description can further cause that the problem solving becomes difficult for someone that arrives later to the PPL work, to understand what actually happened. For an outsiders point of view it also becomes difficult to understand the description. Further, a poor description causes difficulties for someone who picks up the PPL later when it has been closed.

If the description is insufficient it will be difficult to find the root cause. The problem description is after the Q3 report the starting point for the root cause analysis at GKN.

The authors have noticed that the purpose of why a problem description should be made sometimes is unclear. If the team can not see the purpose of it, it is likely

that employees will not put the effort that is needed to make a sufficient description. Some argue that as long as the team members understand the description when the PPL is performed, it is enough.

There are some instructions that the practitioners always should get a habit of entering and those are descriptions from the Q3 about the identified non-conformance such as: where the problem was identified, how many products were affected, where on the material the non-conformance was located, how many errors there was on the product etc. In addition to the information from the Q3 the problem description should break down the problem into the "real" problem and not just contain symptoms of the problem. Pictures of the problem should be attached and a reachable goal or target for the problem solving should be suggested.

Today according to the interviews the PPLs are not being reviewed after they have been finished, therefore some of the practitioners do not feel the need of doing it properly. Either the employees find the importance of doing it properly or there might be a need of controlling old PPLs. Preferably is that the practitioners improve the use of the method by finding the need.

5.2.3 Different Views on How to Use the PPL Template

As mentioned in the section 5.2.2, there are different views on how accurately the PPL should be performed. An interviewed Production Manager argues that it is better to just do it briefly than not at all and he might have a point in that. However, the cost of not doing it properly might be that the problem reoccurs since the root cause was not found by not using the PPL to its full potential. To not find the root cause is costly, thus it might be worth to educate and emphasize the importance of proper usage of the problem solving tools.

5.2.4 Root Cause Analysis is Not Always Performed According to Literature

As described in the empirical findings chapter GKN is working primarily with 5 Why to identify the root cause. However, the authors have found that the employees do not use the method to its full extent, meaning that only one why is asked sometimes and that it rarely goes to five. This leads often to that the true cause is not being reached (Liker & Franz, 2004; Sondalini, 2016). Further, the company is working with 5 Why as a straight line, finding one answer for a why question and continuing on that path. That works if you are absolutely determined that there is only one answer to each why question (Liker & Franz, 2004; Sondalini, 2016). However, it is preferable to use a Why tree as illustrated in Figure 2.5. Then each why question can lead to several answers and the answer that seems to affect the most should be the one that the why questioning continues with. Now it seems more like GKN is taking "the easy way out", but it leads to more work in the end and the risk of reoccurring non-conformances.

If the root cause that is presented is wrong it can lead to that the measures those are introduced do not solve the true problem, but mainly reduce symptoms in the best case. When measures have been presented in the PPLs they are supposed to become monitored and standardized. If the measures are wrong there is no need to implement them and only costly for the company. Since GKN has reoccurring non-conformances every year the 5 Why method is something that the company should learn to work with better in addition to other root cause analysis methods such as the fishbone diagram and is-is not (Bergman & Klefsjö, 2010; Knuts, 2015).

Today the majority of root cause analyses is performed using the 5 Why. Other root cause analysis tools should be available and guidelines should be created rather than instructions on how to do the root cause analysis. Further, employees should be given the autonomy to choose method. This could make them more motivated due to the increase of freedom. This can enable the creativity and creative thinking skills necessary to find the root cause (Amabile, 1998).

5.2.5 Root Cause Analysis is Sometimes Based on Assumptions

Based on the survey, half of the respondents say that assumptions are used to determine the root cause of problems. Bergman and Klefsjö (2010) emphasizes that decisions should be based on facts rather than assumptions to avoid random factors to be of decisive importance. Worth mentioning is that facts not necessarily are numerical data, but that it also can be verbal knowledge and experiences from employees (Bergman & Klefsjö, 2010; Öberg, 2015). By not using an evidential root cause analysis the risk of not finding the root cause of a problem increases (Sondalini, 2016). By using data hypothesis of the root cause it can easier be identified and symptoms can be rejected and disregarded. Something that GKN hereafter should always take note on is to base their decisions on facts.

5.3 Not All Containment Actions Solve the Initial Problem

Only containment actions related to the root cause should be on a PPL. At a PPL there are often a number of root causes listed, this results in a growing list of containment actions to solve the problem. In addition, the list of containment actions is used to collect issues related to the problem, which it should not be. The long list of containment actions takes a long time to resolve and all actions are not necessarily related to the cause.

If the root cause analysis is not performed properly it may result in several root causes (Bergman & Klefsjö, 2010; Liker & Franz, 2004; Sondalini, 2016). To resolve these root causes many containment actions are required, often several for each root cause. This causes a growing list of containment actions which takes time to resolve and it happens that there is not a sufficient amount of resources, which is argued

by employees at GKN.

Not appropriate available resources is an obstacle when creating an creative problem solving environment (Amabile, 1998), a creative environment is desirable when working with complex problems..

Table 5.1: List of containment actions on a common PPL

Containment Actions
Containment Actions for the Root Cause
Containment Actions for Symptoms
Extra Actions for Improving the Process

It is important to distinguish the root cause and issues those are related to a problem (Sondalini, 2016). Issues related to a problem those are known not to be the root cause should not be treated as a root causes at the PPL. They should be treated separately. If they are not it will take longer to resolve the problem due to that issues not related to the root cause of the problem are taking resources from the solving of the true root cause.

However, it is good to continuously have suggestions for improvements (Bergman & Klefsjö, 2010), but these related issues need to be treated separately. In manufacturing at Disc it was observed that they use a form called Change Request. This form should be used for all issues those are not related to the root cause at a PPL. If this form collects all other issues, the PPLs and problems may be resolved faster and resources will be given to solve other problems.

5.4 Relevant Education

As found in the survey, 80 % of the Operators do not agree that there is enough education available. The problem may not necessarily be absence education, but it can be the absence of relevant education or that the availability for the Operators is not good enough.

Management should decide that a survey should be made for the Operators to answer what kind of specific education that is needed (Rubenowitz, 2004). The goal with the education is to increase the work-related competence for each individual in order to keep the employees satisfied and stimulated with their jobs. Education would create both motivation and creativity to identify the root cause and would avoid that problems reoccur (Amabile, 1998; Rubenowitz, 2004).

Suggested is education for Operators, Production Engineers, Production Managers and all others those are involved in problem solving and root cause analysis. The education should emphasize the importance of the planning phase, Q3 report, problem description and root cause analysis. The benefit of making the education relevant for

all the stakeholders is to improve the communication between the roles and the understanding for each other. The group dynamics was something that the Operators were more dissatisfied about than the Production Engineers. By getting a better understanding of each others work, this factor might be reduced (Amabile, 1998). A hypothesis is that bad group dynamics is a symptom of bad communication. By improving the the communication, the group dynamics might improve.

6

Discussion

The following chapter discusses some of the issues GKN needs to consider in order to reach a state of enhanced problem solving; such as Operators' dissatisfaction, that Q-Roles are not entirely incorporated and the role of management. The chapter ends with discussing how parts of the survey was created and how it may have affected parts of the findings.

6.1 Root Cause Analysis and Problem Solving in Practice

In a perfect world, if a non-conformance was identified the production would stop and all resources would focus on collecting and analyzing all possible data related to the problem in order to reach a solution of the problem. Everybody knows that this is not possible, even if a non-conformance is identified the machinery must go on, but there needs to be a balance to coop with the non-conformances those are a part of the normal daily work. The processes need to be built around that non-conformances can occur and how to get the best available prerequisites on how to manage them. In 2015, several Q3 reports were created. All of them needed to be managed in the best possible way. The ability to find the balance of how much time and resources that should be required would become improved by education and experience. However, the efficiency in production to solve problems will not reduce new non-conformances, only the reoccurring ones. As mentioned in the Introduction chapter, problems are also good and they help a company to develop. That stays true for the new non-conformances.

6.2 Dissatisfaction Among the Operators

By taking a holistic view of the results from the survey performed in this thesis, the Operators are in general more dissatisfied than the Production Engineers when asked about problem solving. There is a situation of "we and them" between the roles. The communication and group dynamics is not perfect. By involving the Operators more, enabling education, and making the information more transparent, the situation might get better between them. The feedback to the Operators of the affected operations can easily be improved.

6.3 Q-Role Not Entirely Incorporated to the Value Streams

Having a Q-Role is a good initiative in order to reduce the barriers between Operators and Production Engineers. GKN should continue to develop the role and dedicate more time for quality work for these employees. Proper education for the employees who are taking on this role is essential. However, even though they have the authority to create a PPL by themselves, they should not take the habit of performing them on their own. They should still create a proper team to get the cross-functional expertise to identify the root cause in an efficient manner. The value streams those do not yet have incorporated the role are recommended to do so and learn from the Value Stream Disc, which is the one using it today.

6.4 Tiger Team to Assist in Problem Solving

In Swedish health care queues have been reduced widely by analyzing and understanding the variation of the queues. Where the queues were long, but the variation of new patients was low, the queues were reduced remarkably by making efforts of extra doctors (Jacobsson, 2010). This type of effort should be performed at GKN in order to decrease the pile of problems.

A Production Engineer at GKN suggested that a specialized group should be developed in problem solving, with knowledge of methods and tools to find the root cause. That could have a similar effect such as the Swedish health care did on reducing the queues. According to Wheelright and Clark (1992) a Tiger team is defined as an autonomous team, independent from the organizational layout. The Tiger Team has good knowledge of the organization and processes, but it is not working according to the traditional processes. The team members work autonomous across the organization.

The Tiger Team can have two purposes, first help to reduce the pile of unmanaged problems and secondly to support the value streams in finding the root causes. The value streams have a pile of not yet managed problems that they could need help with reducing. Today GKN has no resources to do so. When one problem is solved another appears. For instance, as mentioned in the empirical findings at 4.7.4 Disc has a constant level of unmanaged problems. A Tiger Team could in this situation give extra resources to reduce this level.

The Tiger Team has the benefit of being unbound to the value streams, and can except from balancing the level of unmanaged problems transfer knowledge between the value streams and get a holistic perspective of the organization. As it is today the Quality Department has a similar role to the insight in the whole organization, but it does not have the resources to dedicate its employees to problem solving due to other duties.

6.5 The Role of Management in the Transition to Enhanced Problem Solving

To be able to find the root cause often requires more time early in the problem solving. The Operators need to get more responsibility in the Q3 reporting and problem solving. Technical Engineers need to be flexible to help the Production Engineers when needed. Finally management needs to create the opportunities to make it happen, first then can the improvements be expected. Management should emphasize quality work, by allowing time for identification of the root cause, and not only push for delivery. The value stream Disc is more dedicated to problem solving and quality work than the others. Disc should be looked upon as a good example by other value streams.

This study could improve the internal quality in the production. This should create an interest in the organization, however when trying to get interviews and make people respond to the survey that the authors created the authors had struggles with getting the Production Managers attention. The Production Managers did not always free time for their Operators and Production Engineers to answer the authors questions. Therefore the percentages in the empirical findings may not reflect the opinions in the company to a hundred %. Still the authors feel confident that 30 people was a big enough sample size in the survey for this research.

The Top Management is aware that the number of new and reoccurring Q3s need to be reduced, the next step is to investigate how, to investigate the recommended improvements in this thesis is a step in the direction.

6.6 Discussions of the Used Methods

This section concerns the validity of the research by discussing the results of the survey.

6.6.1 PPL and 8D in the Survey

When asking the closed questions in the survey, many of the questions were asked concerning both 8D and PPL in the same question. Such as "What do you think of the work with PPL/8D?". At an opened ended question, a Production Engineer brought up a lot of complaints regarding the 8D, and at the same time gave the PPL positive credits. Taking that into account, it might have been a mistake to ask about them together, since it might not give a correct view of both of them. However, the authors do not think it has affected the outcome of the research too much.

6.6.2 Distribution of Respondents in the Survey

Figure 3.2 shows that the number of respondents is not evenly distributed between roles and value streams. The authors have assumed that the answers were representative for the whole production in general. There is however a risk that the employees that have not answered the survey had another opinion. More responses from the roles and all the value streams are needed in order to be entirely sure that the result that is presented in this thesis is in fact representative.

7

Conclusion

The purpose of this last chapter is to conclude the purpose of the thesis by answering the Research Questions. In addition, a contribution to research is described as well as recommendations for future research.

7.1 Concluding the Thesis

The purpose of this research at GKN was to explore and map what the problem solving and the identification of the root cause in manufacturing looks like today, and to identify improvement areas to avoid that a problem reoccurs. By answering the Research Questions stated below the objective of the research was fulfilled.

RQ1 - How do GKN work with identifying the root cause of problems in manufacturing?

At GKN Operators report when a problem has occurred in the IT-system in SAP. The report is called a Q3. When there is time to deal with a problem a team is gathered and a PPL is being performed to find the root cause of the problem and corrective actions to solve it. To find the root cause the tool 5 Why is used and occasionally also fishbone diagrams. What the authors have seen is that the Q3 reports sometimes are poorly described. This makes it difficult to understand what the problem originally was. Engineers occasionally have to search for better descriptions in production which stresses the Operators. Further the authors have seen that the problem descriptions for the PPLs can be vague and this leads to that problems are not being broken down to the level needed to reach the root cause. The consequence of not emphasizing on the problem characterisation, is that the bigger picture of the problem might get lost, there needs to be an allowance of zooming out from the symptom before defining what the problem was. The root cause of the problem can generate a lot of symptoms, which can result in non-conformances in the production. By only focusing on the individual symptoms it will be difficult to find the root cause. Further, 5 Why is not always used in the right way with the enough amount of why questions. This can result in not finding and solving the root cause and the problem can reoccur. Also it has been noticed that employees try to squeeze in as many corrective actions as possible in a PPL, those do not necessarily solve the problem. This is also problematic. The Production Engineers say that there is not a sufficient amount of time to work with problem solving. The Operators say that the communication between Production Engineers and them does not work well

enough. Further the group dynamics is also not functioning to its full extent. In addition, the Operators say that there is not a sufficient available amount of education.

RQ2 - What would an improved process of identifying the root cause look like?

The Q3 reports should be better described in order to facilitate the PPL work later, and to get a grasp of what the problem truly is. If you do not know what has occurred, how can you then move on? Further the PPL descriptions can be improved. It should always be clear, when reading a PPL description, what has happened. After this step focusing on the right thing, finding the root cause, should be the priority. The reason for why a problem occurred should be investigated and the company should try to avoid firefighting as much as it possibly can. The root cause analysis breaks down the cause of the problem properly to the identification of the true root cause. This makes it possible to identify and implement countermeasures to avoid the non-conformance to occur again.

RQ3 - What can GKN do to improve the identifying of the root cause?

Here follows some suggestions for what the company should improve: GKN should prepare education for all Operators, Controllers, Production Engineers, etc who are involved in problem solving. The education should contain information on how to work with problems from the start, with the description of problems to the root cause analysis and the finding of containment actions and how to implement them. In detail this would mean that Q3 reports have to be properly filled out. Making more rigorous problem descriptions should also be a requirement in PPLs; one sentence is simply not enough. Guidelines and instructions should be provided to improve this. Further GKN should improve the PPL root cause analysis according to literature. The 5 Why tool should be used to its full extent and not just be touched upon. A Why tree could be of use. Further, somehow time needs to be released in these phases of the problem solving. The planning phase needs time, which management has got to allow.

All of GKN should work with getting a unified language when it comes to problem solving and finding the root cause. The authors have seen that what often is missing is the understanding of the purpose of the structure of working with problems among the employees. GKN should truly take the responsibility to explain during the education why this work should be done; not just say do this but also explain the purpose in order to get everyone on board!

GKN is doing a good job. Their products are delivered to its customers on time and with high quality, however there is room for improvement on the way to delivery and for the internal quality. This is something that GKN should take note on.

7.2 Contribution to Research

This research contributes to a case study on problem solving and root cause analysis in a low volume manufacturing company. It illuminates the importance of using problem solving tools properly to enable the identification of the problem. It also illuminates the consequence of taking the shortcut of not describing a problem properly early on in the problem solving. Further, it shows what factors that can affected the usage of the tools.

7.3 Recommendations for Future Research

In this section the authors give recommendations on future research which can be valuable in the future for GKN in order to reduce the number of non-conformances.

Research the true cost of reoccurring non-conformances

This research illustrates that reoccurring non-conformances exist and that they bring cost to the company. The authors think that it should be investigated how much reoccurring non-conformances cost for the company.

Study how the process of implementing the countermeasures can be improved

The next step after improving the description of the problem and the identification of the root cause is to identify and implement countermeasures and to standardize them. The researchers did not have time to investigate this. These stages however, would be interesting to research further, since it is not until the countermeasure is implemented and standardized that the organization truly can expect the problem to vanish.

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A

Appendix

A.1 Example of Interview Questions

1. Vad arbetar du med?
2. På vilket sätt jobbar du med problemlösning?
3. Anser du att problemlösningsprocessen fungerar bra?
4. Hur får ni nys om era problem – hur uppdagas de?
5. Hur adresseras de?
6. Arbetar ni med faktadriven problemlösning?
7. Finns det problem som är komplexa för er att lösa i värdeflödet?
 - (a) Exempel?
8. Samarbetar ni med kvalitetsavdelningen när ni löser problem?
 - (a) Hur ser ett sådant samarbete ut?
9. Känner du att det finns nog med resurser att lösa komplicerade problem?
 - (a) Vilka resurser anser du brista?
10. Tycker du att det ibland saknas rätt kunskap i teamen?
11. Vilka medlemmar består ett team normalt sett av, som arbetar med problemlösning?
12. Tycker du att det finns barriärer mellan operatörer och PT?
13. Besöker man hårdvaran när det sker ett fel?
14. Hur funkar det med PR-handläggarna? Vilka är de och vad gör de? Är PT & PR samma sak?
15. Hur tycker du att arbetet med PPL:er fungerar? Utförs de på rätt sätt
16. Tycker du att PPL:er görs i rätt utsträckning? - Tillräckligt ofta/sällan?
17. Hur viktig tycker du problembeskrivningen är?
18. Skaffar man fakta att man har hittat RC innan man börjar med åtgärder?
19. Hur ofta vet man vad problemet är innan de börjar med PPL:en?
20. Händer det att ni identifierar åtgärder som inte är en åtgärd för grundorsaken?
21. Finns det nog med tid att identifiera rot-orsaken av problem?
22. Hur fastställer ni att ni är färdiga med problemet, att det är löst?
23. Kan du nämna några framgångsfaktorer vid arbete med problemlösning?
24. Anser du att det har någon påverkan vem som driver problemprocessen?
 - (a) På vilket sätt?
25. I vilken utsträckning arbetar operatörer självständigt med PPL:er?

A.2 Survey Questions

Hur tycker du arbetet fungerar med att använda PPL/8D? *

☒ Mycket bra

☐ Bra

☐ Dåligt

☐ Mycket dåligt

☐ Ingen åsikt

Efter hur lång tid börjar man vanligtvis arbeta med ett nytt inrapporterat problem? *

☐ Samma dag

☐ 2-3 dagar

☐ 3-5 dagar

☐ 1-2 veckor

☐ 3 veckor eller längre

Hur ofta är arbetar du med problemlösning i tillverkningen? *

☐ Varje dag

☐ 2-3 dagar i veckan

☐ 1 gång i veckan

☐ Ett par gånger i månaden

☐ Mer sällan

Figure A.1: Survey page 1

Hur fungerar arbetet vid problemlösning (PPL/8D) med att ...? *

	Mycket Dåligt 1	2	3	Mycket bra 4	Ingen åsikt
Beskriva och bryta ner problemet?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sätta upp mål för problemlösning? (mätbara, nårbare och tydliga)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Identifiera och införa omedelbara åtgärder?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Identifiera grundorsaken till problemet?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Identifiera åtgärder till grundorsaken?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Införa åtgärder för grundorsaken?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure A.2: Survey page 2

II

Hur väl stämmer följande påståenden överens med din uppfattning? *

	Stämmer inte allts 1	2	3	Instämmer helt 4	Ingen åsikt
Problembeskrivningen är baserad på antaganden snarare än fakta.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
De som arbetar med problemlösning besöker problemlplatsen.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Man följer upp att införda åtgärderna löste problemet.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Man inför åtgärder innan man utrett grundorsaken.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Man standardiserar åtgärderna i verksamheten.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure A.3: Survey page 3

Hur väl stämmer följande påståenden överens med din uppfattning? Forts... *

	Stämmer inte allts 1	2	3	Instämmer helt 4	Ingen åsikt
Jag känner mig motiverad att arbeta med problemlösning.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Det finns tillräckligt med tid att arbeta med problemlösning.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Det finns tillräckligt med utbildning om problemlösning.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Påverkan är stor beroende på vem som leder problemlösningen.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Informationsmöten kring problemlösning ställs ofta in.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure A.4: Survey page 4

A. Appendix

Hur stämmer följande frågor om förutsättningar för problemlösning överens med din åsikt? *

	Stämmer inte alls 1	2	3	Instämmer helt 4	Ingen åsikt
Tillräcklig kunskap finns i gruppen vid problemlösning.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gruppdynamiken fungerar bra i problemlösningsarbete.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Berörd personal blir informerad att det har skett en avvikelse.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kommunikationen fungerar bra mellan Operatörer och PR-handläggare/PT.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Jag känner mig motiverad att rapportera när ett problem har uppkommit.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure A.5: Survey page 5

Hur många medlemmar ingår normalt i ett grupp vid en problemlösning? *

1 ▾

Vad tycker du om antalet medlemmar som arbetar normalt i en grupp vid problemlösning? *

☐ För få
☐ Lagom
☐ För många
☐ Ingen åsikt

Hur skulle arbetet med problemlösning kunna förbättras?

Har du erfarenhet av andra problemlösningssmetoder förutom PPL/8D?

Figure A.6: Survey page 6

I vilket värdeflöde arbetar du? *

- ☐ Disc
☐ Fabrication
☐ Structures
☐ LPT/Spool
☐ Cases
☐ Special Products
☒ Specify your own value:

Vad har du för roll? *

- ☐ Operatör
☐ Kontrollant
☐ PT
☒ Specify your own value:

Har du något av följande ansvar? (Frivillig)

- ☐ Q-Roll
☐ PR-Handläggare

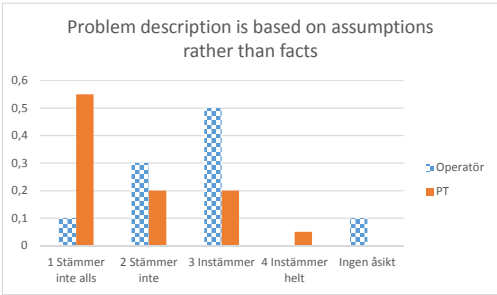
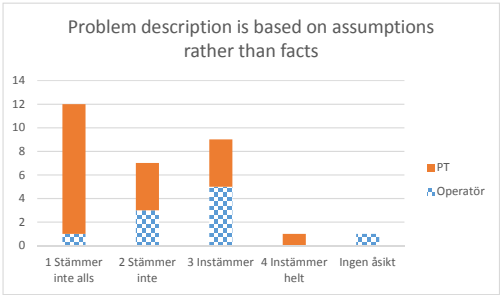
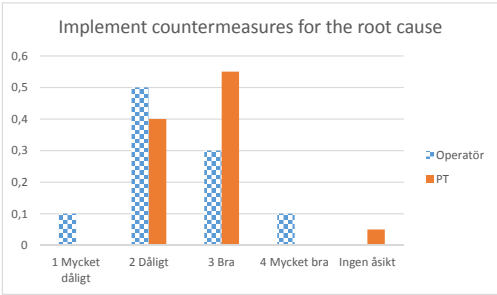
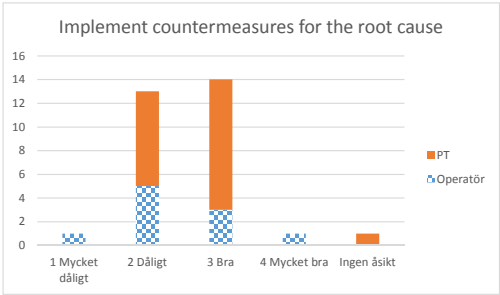
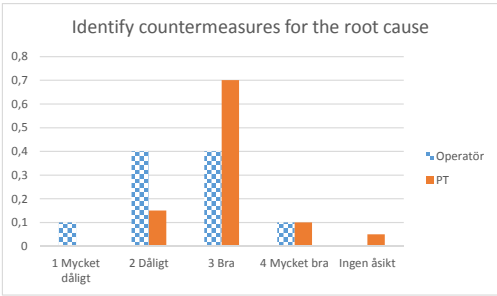
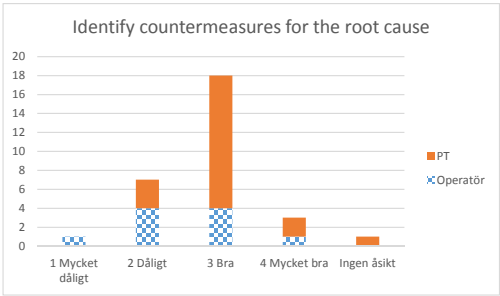
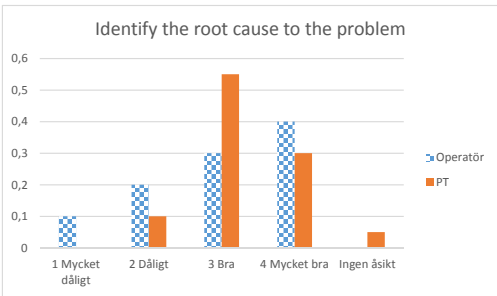
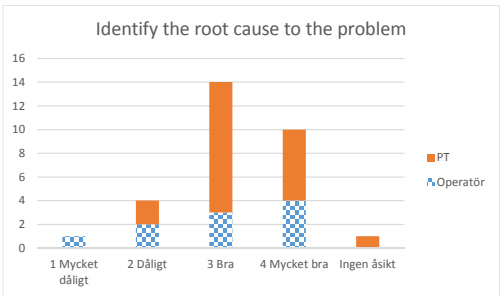
Övriga kommentarer/synpunkter (Frivillig)

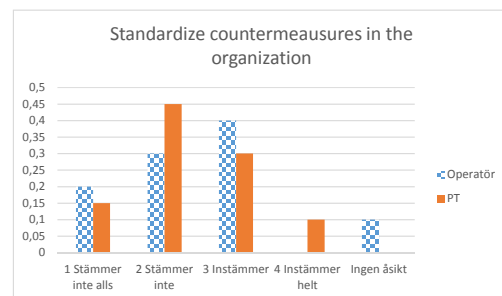
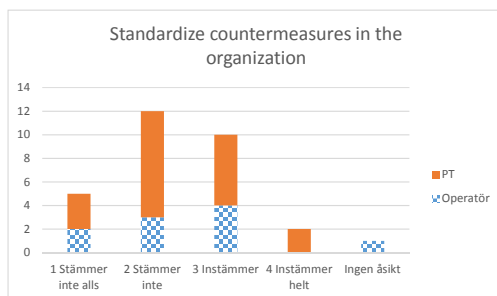
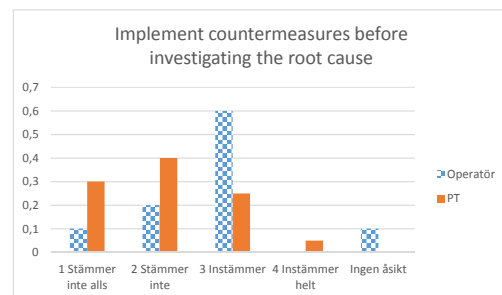
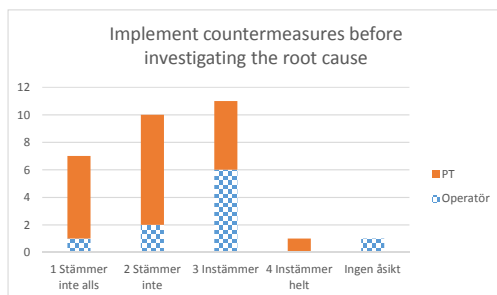
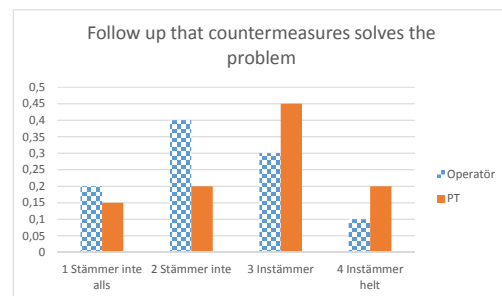
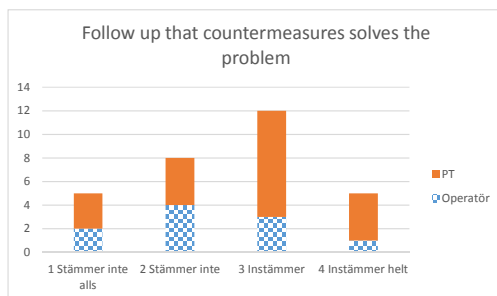
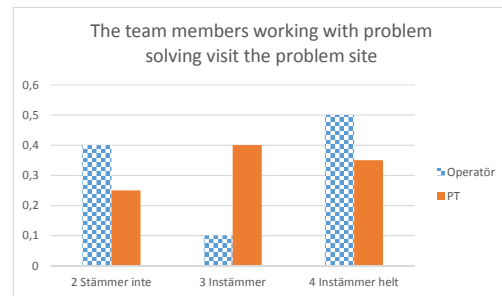
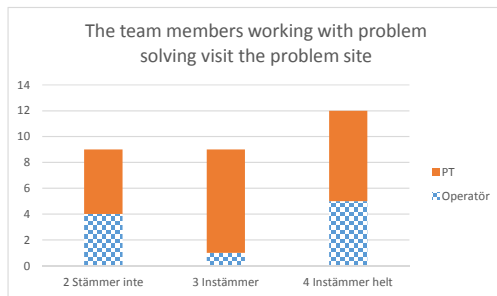
Figure A.7: Survey page 7

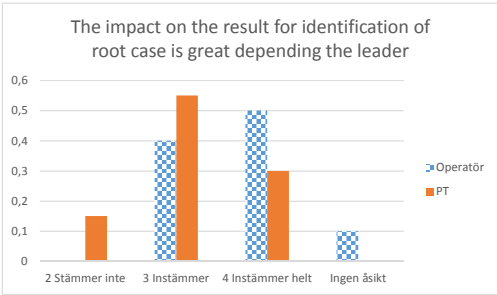
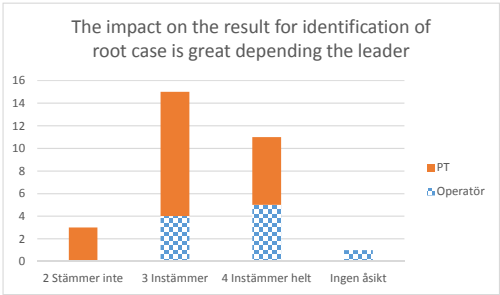
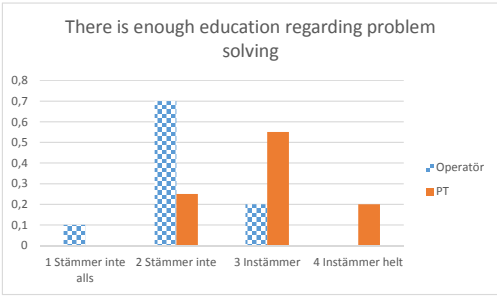
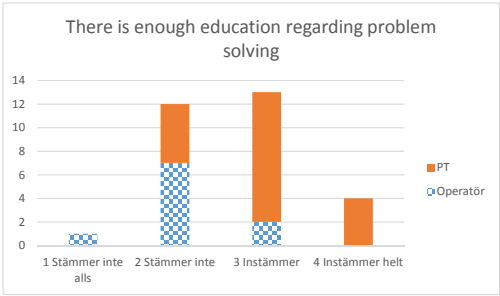
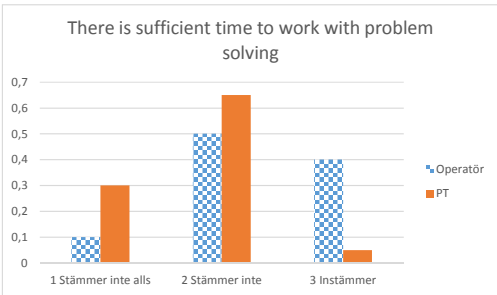
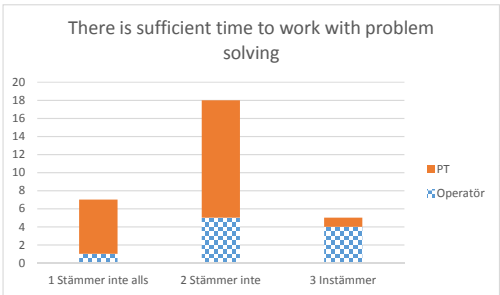
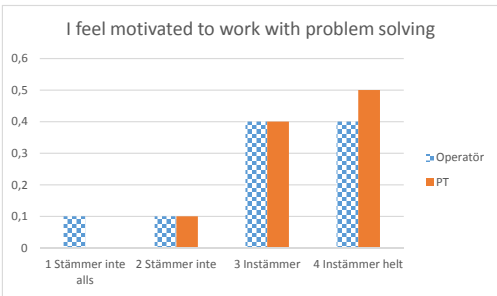
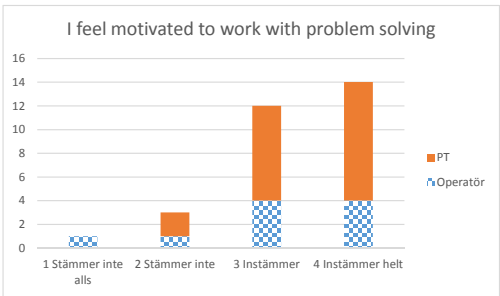
A.3 Survey Results

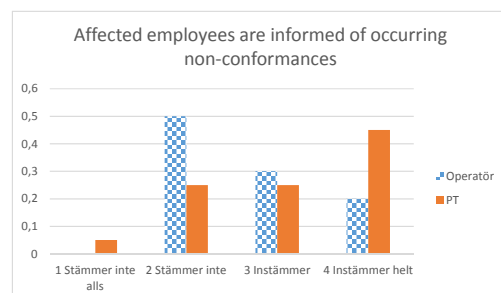
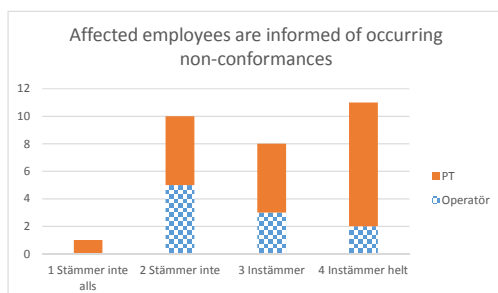
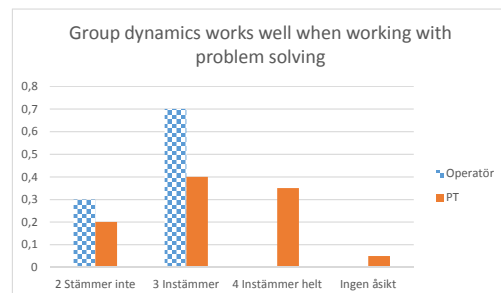
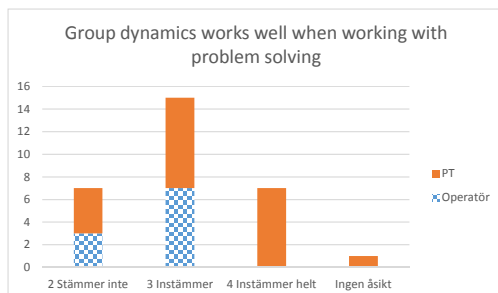
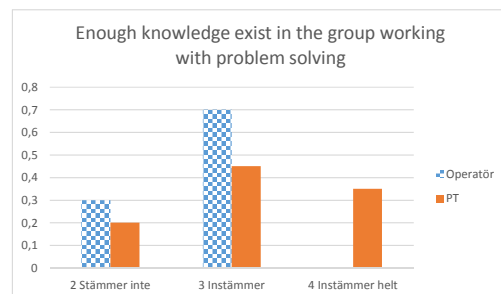
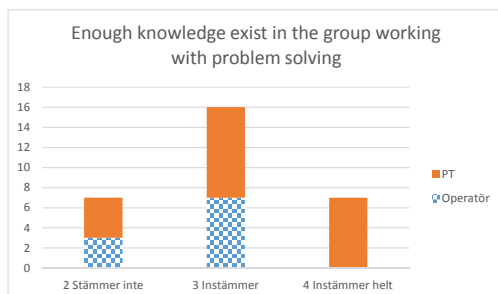
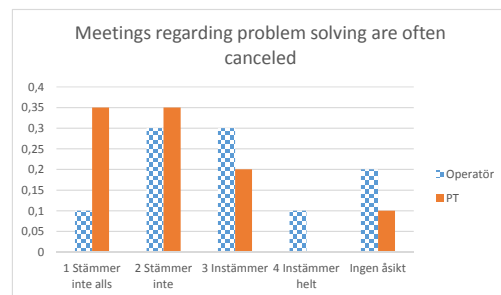
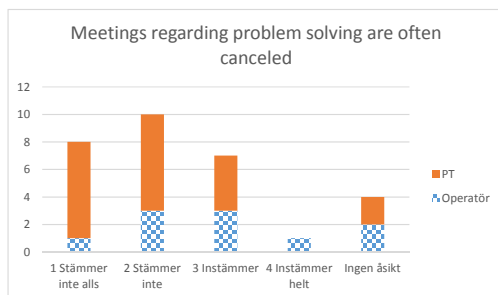


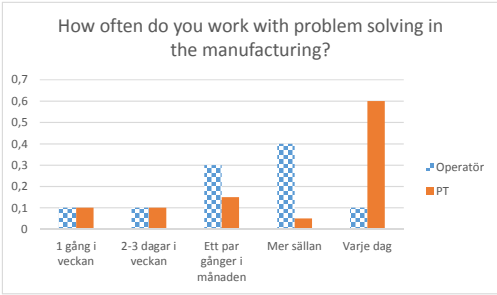
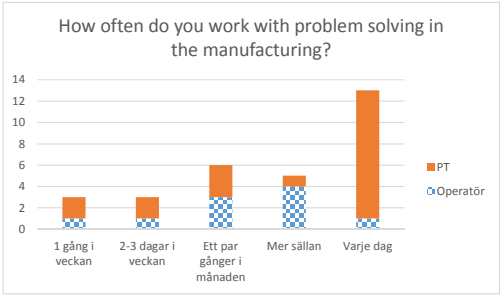
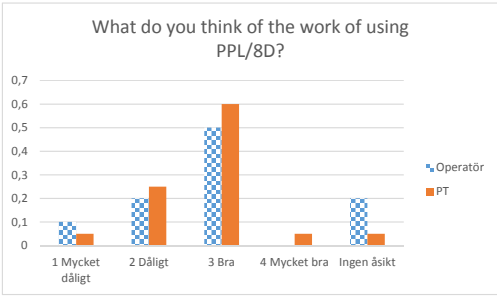
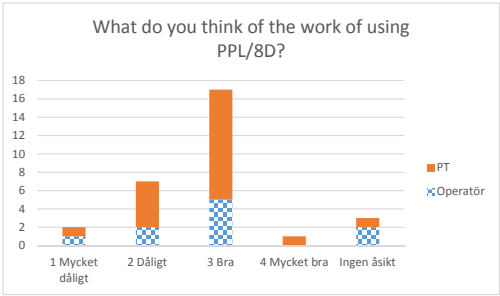
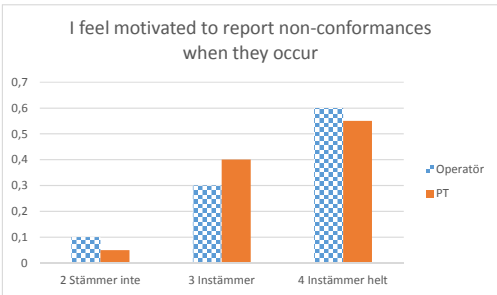
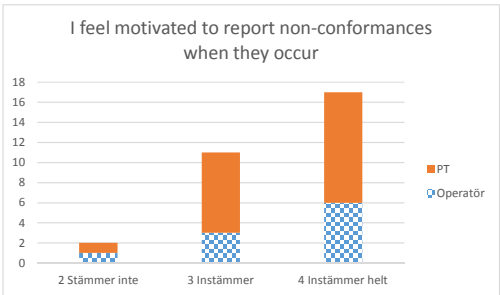
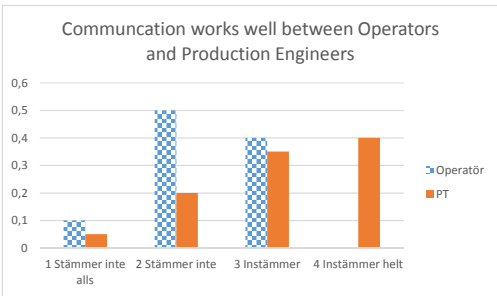
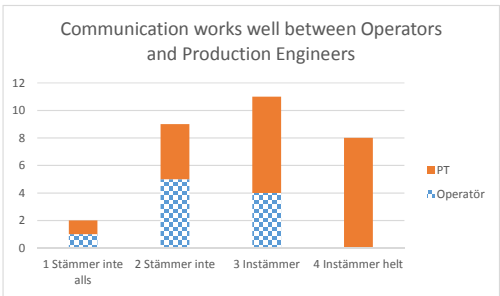
Figure A.8: Survey Results











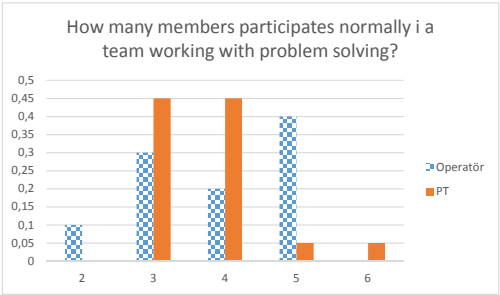
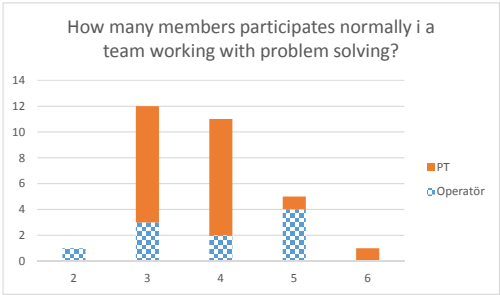
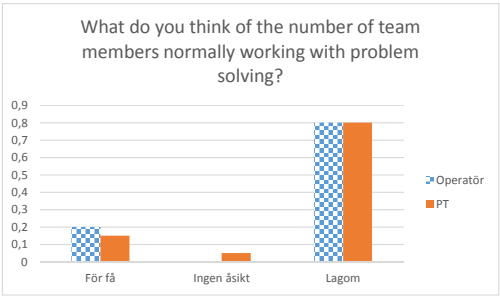
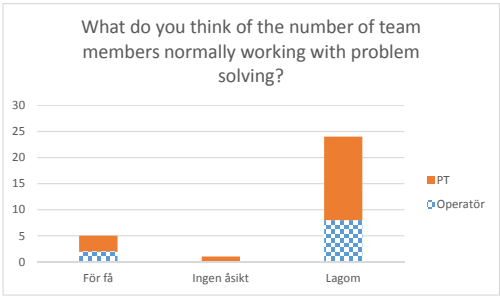
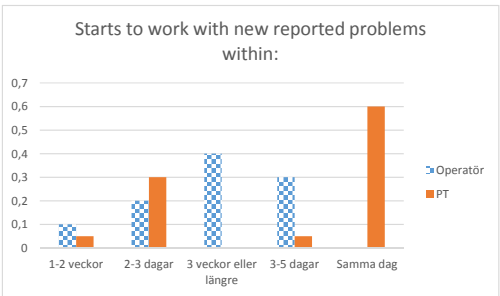
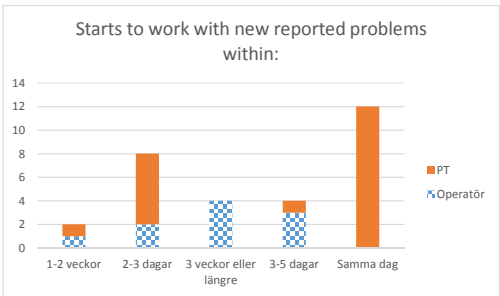


Figure A.9: PPL Template

[illegible]

Grundorsaksanalys samt plats för anteckningar och annat som bilder, skisser etc.

Deltagare:

