Applying Lean Service Concepts to the Fault Reporting, Analysis, and Corrective Action System: A Case Study at an Engineering Firm

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Abstract

As a general rule, companies have focused most of their improvement initiatives in manufacturing and operations, leaving their internal service processes behind. This study presents a Fault Reporting, Analysis, and Corrective Action System (FRACAS) process which is underperforming in terms of lead time. The process is studied in detail and the people who work with it were interviewed to find out how they think the process inhibits their work. The contribution this study makes is that it provides an example of what lean FRACAS could mean. The studied process presents itself as non-compliant with what the employees wish from such a process. This in turn causes these employees to underperform since they think that the process does not seem to provide value to neither themselves nor the customers.

Keywords: Lean service, internal service, FRACAS, process improvement, continuous improvement
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Acronyms

BD  Business Development
CAR  Corrective Action Request
CI  Continuous Improvement
CM  CAR Manager
CO  CAR Owner
CR  CAR Resolver
ERP  Enterprise Resource Planning
FRACAS  Fault Reporting, Analysis, and Corrective Action System
FRB  Failure Review Board
JIT  Just-in-time
NC  Nonconformance
NCR  Nonconformance Report
NNVA  Necessary but Non-Value Adding
NVA  Non-Value Adding
PAP  Parts Approval Process
PDCA  Plan-Do-Check-Act
PQA  Project Quality Assurance
QA  Quality Assurance
SEAP  Supplier Evaluation and Approval Process
SQA  Supplier Quality Assurance
TPS  Toyota Production System
TQM  Total Quality Management
VA  Value Adding
VSM  Value Stream Mapping
WCC  Warranty Customer Coordinator
1 Introduction

Companies are generally bad at applying their own improvement strategies to their internal service processes (Maleyeff, 2006). The numerous operations strategy initiatives that have been mentioned in research are usually limited to shop floor applications (Fullerton et al., 2013). Just-in-time (JIT), Total Quality Management (TQM), Six Sigma, and most commonly, lean manufacturing is and has been the go-to approach to production in today’s business climate for many years now (Burton and Boeder, 2003; Shah and Ward, 2003; Cottyn et al., 2011, for example). There is much to be gained from applying the lean production ideas to the support processes inside an organization, called internal service processes, (Maleyeff, 2006) since poor service usually means that most problems are recurrent (Radnor and Johnston, 2012).

Recurrent problems can be eliminated by identifying the root cause and implementing corrective actions, which is the goal of Fault Reporting, Analysis, and Corrective Action System (FRACAS). FRACAS is a theoretical concept of an internal service that tracks all types of issues. It has the goal of setting cost-reducing directives in the short term improving quality in the long term (Cota and Gullo, 2013). An internal service is a process that is carried out inside an organization and provides support for the core business activity, for instance performance tracking. The essence of this particular internal service is that it records many different types of data for any type of faults or nonconformities and analyzes that data to provide grounds for actions to be taken in order for the fault not to happen again. FRACAS is a fairly common tool in technologically advanced industries and involve many different functions and roles in an organization (Lee et al., 2010). That also means that there are a number of issues attached to this tool for improvement. Complex organizational channels for interaction and different objectives for different business functions can affect the performance of the tool (Hallquist and Schick, 2004) which causes limited performance.

Existing research on FRACAS has a main focus on the different aspects of the theory itself, rather than how to improve an application of it using existing improvement strategies. On the one hand there is a research gap concerning lean FRACAS. On the other hand, there is much research on internal service and lean service, which are the two concepts that contribute to understanding the causes of the problems in the Corrective Action Request (CAR) process. Combining all of that is what makes this study unique and presents an idea of lean FRACAS. To be classified as an internal service, one of the main deliverables must be information (Johnston, 2008). Internal services have many common characteristics (Maleyeff, 2006) and using lean to improve service performance has been shown to decrease service lead times (Swank, 2003).
In this study, a customer complaint process, called CAR, in a globally present engineering company has been studied in terms of what causes long lead times of the problem resolution concerning supplier quality. The approach to used to assess the inner workings of the organization has been based on interviews. People in the different functions that depend on the CAR process were interviewed, with the goal of assessing the work flow and identifying hindrances to an effective and efficient process. The industrial management focus in the study has been on the functional level using the individual level as input along with the functional. This means that people’s contributions and take-aways along with the process characteristics together answer the questions raised in this paper. On top of that, the scientific literature that has been studied mainly concern lean service and research about FRACAS which is what CAR is an example of. See Figure 1 for an illustration of the relation between CAR and FRACAS. At the case company, the Project Quality Assurance (PQA) function is responsible for the quality assurance in the on-going projects and reports to the project managers. In turn, PQA depends on different units to resolve quality issues that arise in the projects related to their respective areas. Since some of the departments are functional organizations and others are project organizations, they have different views on the importance of the quality issues. The line organizations are focused on components they deliver to every project and the project organizations are very time invested in their respective projects’ progress. Therefore, the PQA unit’s role is restricted by the speed with which the functional organizations resolve quality issues that concern them, which is what has prompted this study.

<table>
<thead>
<tr>
<th>Service theory</th>
<th>Internal service</th>
<th>FRACAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lean service</td>
<td>Maleyeff 2006; Radnor and Johnston 2012; Swank 2003; Wei 2009</td>
<td>This study</td>
</tr>
</tbody>
</table>

Table 1  This matrix shows the main existing research in process theory, FRACAS, and lean service used in this study. Process theory provides the background while FRACAS and lean service research are applied together to form lean FRACAS.
Figure 1 Illustration of how the different terms are related to one another. CAR is an application of FRACAS, and FRACAS is an internal service. Lean service is the improvement tool used in this study to identify the causes of long lead times.

1.1 Empirical Context

The problem at hand concerns process improvement and specifically the process that governs how customer complaints are dealt with. When a customer reports a non-conformity, a request for corrective action is created and should be resolved within 28 days. However, the Supplier Quality Assurance (SQA) function has difficulties reaching this target due to a number of reasons. First of all, the communication with an internal customer is not at a satisfactory level, which affects the level of detail and attention on the nonconformity reports. Secondly, there is no prioritization practices in place for handling requests, meaning that e.g. loose tape has the same priority as malfunctioning major circuitry. Thirdly, this process has a low interest both from the organization itself and from its customers.

One aspect that is inherent to the SQA function’s situation is the fact that all of their issues have to do with external parties. As such, the control that SQA has over its issues is quite limited compared to other units in the organization, which can solve a majority of its issues within the organization since they do not have any direct contact with external parties. This means, in turn, that every case handled by SQA has much more complex channels to go through to resolve their issues.

This problem area is quite contextual but is also part of a larger issue, namely internal service process improvement. This process is a FRACAS process with underperformance issues, and the process’s design is not aligned with what the company’s own operations strategy. Therefore, the focus in the study is on internal services with the context being research domain of FRACAS, an example of an internal service.
1.2 Objective and Research Question

This study aims to use lean production lessons to investigate what is causing poor performance in a FRACAS process and to suggest improvements according to the lessons from the lean production’s service application. This application of lean is called lean service. Expanding on that the objective is, through a high on-site presence at the case company, to make sense of why the process is underperforming. Making sense of the process here means to outline how the process works compared to how it is designed to work and to use people’s opinions of how the process design affects them negatively. These negative parts of the process are then presented with improvement suggestions based on the operations strategy primarily used at the case company, lean, as mentioned earlier.

The research question in this thesis is: How can lean service be used to identify areas for improvement in a FRACAS process in order to increase performance?

The objective and research question have been reached by studying the FRACAS application called CAR. The investigation in this study takes into account the ‘soft’ aspects of the CAR process, such as the employees’ perception of the process’s usefulness, as well as ‘hard’ aspects in terms of the design of the process.

1.3 Delimitations

As stated before, this study focuses on two things: process design and employees’ perception as seen through a lean service looking glass. This means that the fact that functions other than the SQA where the CAR process works quite well have not been studied, but the fact that it works well is discussed.

Only internal aspects will be considered for the analysis, that is, things pertaining to the process itself. External issues like supplier contracts and relationships, as well as local resources like people, are not part of the study although such aspects have a clear involvement in the process’s performance due to the nature of networks.
2 Methodology

This thesis is an in-depth study; it will take into account the complexities that surround the CAR process and its people. Depth is a basic criterion in order to be sensitive to the subtleties and nuances of in what way people perceive a process (Kempster and Cope, 2010). These subtleties and nuances are here provided by author presence in the case company’s office for a majority of the time for the duration of this study. In order to understand the studied process, CAR, throughout all of its stages, people who work in the roles that are affected by the work process were interviewed to create a holistic understanding of the process flow and how people feel and think about the process.

The case study method has been used due to the fact that the problem at hand has many contextual conditions, whereby a case study method is appropriate (Yin, 2009). As stated in the Introduction, this study aims to identify barriers to adequate process performance, or in other words, why the process is underperforming in the supplier function at the case firm. Quantitative data and qualitative data together illustrate the dynamics at play for a process’s performance level since contextual conditions affect both the customer focus and individual practices (Sousa, 2003). Because of the depth of the study, individual work habits and opinions, which are difficult to measure, play a large role (Batt, 2012). This calls for interviews where the interviewee can speak freely about how they work with just enough guidance to keep the interview on topic.

The study methodology is based on an inductive approach, which means that the context warrants the theory. The trail of understanding here follows a hermeneutic spiral in terms of understanding-as-you-go, see Figure 2. The research is interpreted and developed as the holistic picture emerges. In other words, the study’s method is built around the concept that understanding the thesis holistically will be determined by reference to individual parts and understanding the individual parts is determined by reference to the whole, thereby evolving the understanding of the problem throughout progression of the research through iterations of knowledge processing. Essentially, details are understood thanks to knowing the whole picture, and the whole picture is understood thanks to the knowledge given by the details. This then creates a spiral where deeper understanding is achieved progressively by understanding each of the two entities, details versus the whole picture, a little at a time.
This section explains and presents the methods used. First the empirical background is presented with a description of the case company, the studied work process, and the functional units that are involved in the process. After that the research design is described, and finally the study’s validity and sources are presented.

2.1 Empirical Background

This study has taken place inside a corporate environment and this section aims to present that environment and the work processes that have been examined as part of the study. First of all, a short description of the case company is presented to put it in perspective. Secondly a short description of FRACAS as the governing theoretical basis as directed by the central organization is described. This subsection also includes a description of the CAR work process, which aims to introduce what the process is and does while the findings from the study of the process is presented in Section 4.

Case Company

The company in which this study has been performed is part of a subdivision of a global engineering corporation located in the middle region of Sweden. The corporation employs about 70,000 people worldwide and has its headquarters in North America. The corporation designs, manufactures, sells, and services its products in two different industries. The subdivision in which this study has been performed employs about 3,000 people and designs propulsion systems which are sold to mainly internal customers, and will be called “ENGINEERING CORP” throughout the thesis.

ENGINEERING CORP has a tool for reporting incoming warranty and nonconformity claims, CAR, which the people who manage the quality assurance in the various projects rely on for information and status. However, this tool was seeing longer lead times and backlogs rendering it less useful for the quality assurance
managers. In particular, cases that have to do with suppliers tend to take long to resolve thanks to the fact that more parties than ENGINEERING CORP and the customers have to be involved. In addition to that, the unit laden with handling CARs that have to do with suppliers has limited time dealing with these cases, causing the cases to pile up and not be resolved.

This thesis suggestion came into existence due to the fact that the quality assurance managers thought that the resolution time needs to be shortened in order for them to do their job.

FRACAS at ENGINEERING CORP

The directive for the CAR process is FRACAS, which outlines the requirements for handling failures in all processes of ENGINEERING CORP’s all organizational units. The directive is in place to increase the reliability and maintainability for current and future projects, track the performance based on corrective actions, contribute to lessons learned, and provide qualitative and quantitative historical data. These outputs are achieved from input in the form of nonconformance reports, repair reports from customer and the own organization, customer requirements, ENGINEERING CORP requirements, and contracts requirements.

This governing process ensures that monitoring is performed on products in service, failures and non-performance is documented and analyzed, and that corrective actions are defined and implemented according to an implementation plan. This was put in place to increase life-cycle cost performance of a certain system or function, ensure a way of systematic knowledge management and transfer between existing and future projects, and to see to that environmental concerns and requirements and safety standards are being proactively covered.

2.2 Research Design

The research was designed as the work at the case company went on. This section begins with a description of the process of how the methodology was carried out, and the subsequent sections describe the different elements of the method. The section is concluded with a short discussion on validity and the sources used in the study.

Research Process

The study started with an undefined objective. The desired outcome was the only expressed purpose of the study and that outcome was to “improve the CAR resolution time” by the PQA managers. To support the original thesis idea drafted by ENGINEERING CORP, a couple of facts were presented to illustrate some ideas for reasons as to why the CAR process was not reaching its target of 28 days resolution time. These ideas were:
Low quality on the communication between ENGINEERING CORP and its largest internal customer, making it difficult to be on the same page concerning how to report and handle nonconformities

- All cases that become CARs have the same prioritization – there is no differentiation between cases
- There is a lack of resources in the SQA unit making it hard to address all the cases that come in
- Neither the customers, the suppliers, nor the organization itself express any interest in handling the CARs better.

In order to narrow down the scope and find a suitable theme to work towards, interviews and informal talks with experienced professionals at ENGINEERING CORP were used. It was clear that what was expected from the company was a combination of qualitative and quantitative analysis of the situation with recommendations for how to proceed to improve it. Other than that, no other constraints or wishes were expressed. The initial period was therefore mostly used to get to know people and the situation through a high presence at the company office.

Studying and gathering data for the CAR process had two parts: internal documentation and interviews. Starting by studying internal documentation about the concerned processes and learning who does what, was the first part of the research, and through it knowledge was gained about how the process is dealt with versus how it is meant to be dealt with. Secondly, interviews were held with key individuals who are either directly involved in the process, or part of supporting functions. After the data gathering, the information was analyzed and compiled so that all concerns and reflections about why the process is being underperformed was outlined. Following the analysis, a literature study focused at the strategic elements at work at ENGINEERING CORP, i.e. lean production, lean service and FRACAS was conducted. This work process of studying the literature after conducting the study is part of an inductive study method. After the literature study, concepts learned were adapted to fit the objective of this study and make up the suggested process improvements.

Interviews

The aim of the interviews was to gather data on the individual level of the process in order to analyze it to find what constitutes the barriers to adequate performance. In order for the interviewees to express what they think is most important regarding their work with CARs, the interviews will be semi-structured to a degree depending on who is being interviewed (Collins and Hussey, 2009). People in the following roles have been interviewed:

- CAR Resolver (CR)
- CAR Manager (CM)
The interviews with the CRs were the largest part of the data gathering. Since CRs have played a larger role in the scope of this study and their work process is reliant on the individual level, the interviews with them were less structured to make sure any nuances or other specific circumstances were communicated clearly. This was because of the fact that the reasons the CRs would give as causes for the long lead times would ultimately represent the most substantial reasons for the large CAR backlog in the SQA function.

<table>
<thead>
<tr>
<th>Role</th>
<th>#</th>
<th>Interview focus</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>2</td>
<td>What is their role in the process, and why they think the SQA CRs underperform</td>
<td>Two COs were interviewed</td>
</tr>
<tr>
<td>SQA CM</td>
<td>1</td>
<td>How the SQA function works with CAR but also in general</td>
<td>One interview with one person</td>
</tr>
<tr>
<td>SQA CR</td>
<td>4</td>
<td>How they work with CAR, why they think they underperform, what they dislike with the process and what changes they would like to see</td>
<td>Two SQA CRs were interviewed twice each.</td>
</tr>
<tr>
<td>Business dev.</td>
<td>1</td>
<td>How processes are developed and improved at the company, and what strategic elements are part of that</td>
<td>One interview with one person</td>
</tr>
</tbody>
</table>

Table 2 A breakdown of who was interviewed and what was the focus of each interview, and the number of interviews with each role.

The semi-structure of the interviews works to keep the interviewees from bringing up hypothetical situations and instead stick to recounting experiences (Collins and Hussey, 2009). Interviews with the top two tiers on the CAR process, the Manager and the Owner, had more structure as their accounts was mainly used to develop an understanding for the process from its start to finish, thus contributing to the holistic view and the hermeneutic spiral of the development of understanding details and the whole picture. The semi-structure of the interviews worked in the way that open-ended questions such as “what do you think about the CAR process?” , “how do you work with CAR cases?” , “what would you change in the CAR process?” , “walk me through your work process as you deal with a CAR”. This means that the interviews were based on examples of experiences the interviewees had had. Essentially, the interviewee was encouraged to think of a situation where the CAR process has worked well and describe how the influence of the CAR process affected the work, or vice versa. The interviewee was then also asked to describe a case where they had felt inhibited by the process, and what specifically in the process it was that had made them less inclined to follow the process guidelines. This technique uses some ideas from the critical incident technique developed by Flanagan in the 1950s (Collins and Hussey, 2009) and is used to collect key facts from the interviewee.
and is a quite rigorous interview method in the semi-structured category. While the interview method used here is less structured than Flanagan’s method, the idea of extracting information from specific events, i.e. examples, is inspired by it.

The questions to the interviewees were of mixed nature. As previously mentioned, questions regarding specific examples are part of the interviews, but also hypothetical and probing questions. The hypothetical element was used so that the interviewee could describe an ideal state for the CAR process in terms of how it could be a more natural and enjoyable part of their daily work tasks.

**Quantitative Data Collection**

The quantitative data that has been collected in this study comes from the software system where the CARs are tracked. This data has mainly been used to support qualitative data, as is common in inductive qualitative studies (Barratt et al., 2011). The information that is tracked in the system is presented in Table 3.

<table>
<thead>
<tr>
<th>Data field</th>
<th>Example value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsible CR</td>
<td>[Name]</td>
</tr>
<tr>
<td>Created by CO</td>
<td>[Name]</td>
</tr>
<tr>
<td>Managed by CM</td>
<td>[Name]</td>
</tr>
<tr>
<td>Customer</td>
<td>[Company Name]</td>
</tr>
<tr>
<td>NCR Cause</td>
<td>e.g. ‘Supplier’, ‘Manufacturing’</td>
</tr>
<tr>
<td>Project</td>
<td>[Name of project]</td>
</tr>
<tr>
<td>Creation date</td>
<td>[Day, Month, and Year]</td>
</tr>
<tr>
<td>Action required by date</td>
<td>[Day, Month, and Year]</td>
</tr>
<tr>
<td>Status</td>
<td>e.g. ‘Open’, ‘On-going’, ‘Closed’</td>
</tr>
<tr>
<td>Days open</td>
<td>Present day - Creation date</td>
</tr>
<tr>
<td>Days to close</td>
<td>Closing date - Creation date</td>
</tr>
</tbody>
</table>

*Table 3*  *The collected quantitative data fields with examples of what is tracked.*

The data from this source has been used to illustrate certain points that the numbers can contribute to. As mentioned above, the purpose of this minor quantitative data collection is to build and support the arguments that come from the qualitative data analysis.

### 2.3 Validity and Limitations

Data is generally divided into quantitative and qualitative. Quantitative data usually has a high degree of reliability, while qualitative data usually has a high degree of validity (Collins and Hussey, 2009). The reason for this is that quantitative data can be reproduced and analyzed objectively while qualitative data depends on contextual variables and has a certain time element which is not always possible to reproduce.
In order to achieve validity in this study, the interpretations from the interviews with the CRs were checked back with them to ensure that nothing used in the study was a result of misinterpretation. All interviews have been recorded to provide confirmability. The recordings also work as a way to revisit the interviews at a later stage when the general understanding of circumstances surrounding what was discussed at the interviews is better; the hermeneutic spiral at work. Since this study has a very low degree of ambiguous definitions that impact the scope, external validity can be seen as less relevant.

The primary sources for this research are the interviews, which have been held with key individuals as described before. The interview data was then be supported using quantitative data from the various statistical data sources available internally.

The secondary sources used in this study are made up of internal documentation at ENGINEERING CORP that describe the CAR and FRACAS processes and directives. These documents are where the information about the process designs, aims, goals and other details about the processes can be found.

The limitations, or bias, in this study is the fact that the commissioner of the study, the PQA function, is a stakeholder in the process. Their position on what the process should produce and the importance of that can affect the angle of the problem definition. Basically the PQA function is dependent on data completeness in order to track their projects’ progress, quality issues on a larger scale in order to keep track of the general project quality levels, and perform their duties towards clients. This means that they have a different incentive to require CAR usage. This limitation’s impact was limited by studying the internal process documentation and simply by being aware of the stakeholder’s position.
3 Theoretical Concepts

The aim of the theoretical context section is to present the findings from the literature review that are either used to analyze the findings or to provide background knowledge or context. The first subsection begins with a description of what a process is, with the purpose of providing a context for lean service, one of the key concepts used in this study when it comes to process improvement. The third and final subsection presents the continuous improvement scheme FRACAS, which is what the CAR process is an example of.

3.1 Process Theory

A process can be seen as having a supplier and a customer and is itself a work flow carried out by its members. One definition of a process is “a limited amount of coordinated activities that together have a determined purpose”\(^1\) (Sörqvist, 2004, p. 101) forming a network of ‘work packages’ that create a flow of work and information. A process is characterized by the following properties (Sörqvist, 2004):

*Processes have a start and a finish*

A process is made up of delimited activities which means that it has a determined beginning and end. This does not mean that either of these need to be internal to the organization.

*Processes have customers and suppliers*

Processes may have both external and internal suppliers and customers.

*Processes are repetitive*

In itself, a process is repeated with a certain frequency. If a process is not repetitive it is more suitably described as a project.

*Processes describe flows in the organization*

Process oriented firms put focus on the fact that processes describe sequences, networks, and flows of activities and work packages that are carried out in the organization.

*Processes create customer value*

Customers are a part of the process and the objective of the process is to create value for them. As mentioned, customers can be both internal and external.

*Processes have purposes and objectives*

Processes exist because there is a demand for them. These demands are the grounds for a process’s purpose and objective.

---

Roles in a Process

As shown in Figure 3 there are three roles in a process: The customer, the producer, and the supplier (Sörqvist, 2004). This way of looking at a process flow is central to the process orientation. When a person’s work is needed for a task, that person is the supplier and the person performing the task acts as the producer. This is then delivered to the next person in line who uses the product created by the producer and is thus the customer. These roles shift as the focus changes; the producer becomes the supplier to the customer, and the customer becomes the producer, who in turn will be the supplier of a new producer, their customer.

![Figure 3](image)

Figure 3  Representation of a process’s three parts containing the three roles: customer, producer, and supplier. Adapted from Sörqvist (2004, p. 103)

Types of Processes

Commonly processes are divided into different classes. These classes are business processes, support processes, and management processes (Gardner, 2004). Business processes are processes that directly create value to an external party, meaning those processes which the organization is measured by as well as exist for and its vision and mission are based around (Sörqvist, 2004). It also relies on an external party for its input and thus both begin and end with external party.

![Figure 4](image)

Figure 4  Types of processes in an organization. A customer need is satisfied by a chain of business processes, which in turn are supported by support processes and managed by management processes. Adapted from Gardner (2004, p. 30).
Support processes exist to ensure that the core activities function and flow efficiently and effectively. Some support processes are specific to the organization while others are commonly found throughout the business world. This fact makes support processes likely candidates for outsourcing (Gardner, 2004). Some examples of support processes are accounting, human resources, quality assurance and control, IT, and legal services. As such, the CAR process is a support process.

Management processes gives the organization direction and governance (Sörqvist, 2004). As the name entails, these processes are typically conducted to the majority by senior officers and managers in includes activities such as development and deployment of strategies, plans, and goals, and business development. Management processes are also the guidance for creating and conducting business and support processes (Gardner, 2004).

Processes can be broken down and defined in different ways. Some organizations tend to have a simple way of defining their processes to the most part within existing functions, thereby creating functional processes. Other organizations seek to employ more cross-functional processes, which are more radical in nature. Furthermore, processes can be defined on a detailed operative level or a strategic level and identified from a customer perspective or a production perspective (Sörqvist, 2004). Moreover a process can be broken down in to smaller parts in order to illustrate a hierarchy within each process. For example, a process can comprise a number of sub-processes each of which have some associated activities. These activities are then made up of individual work tasks.

Why Process Orientation?

It is widely argued by researchers that a process orientation is beneficial to increased competitive advantage instead of more archaic setups such as hierarchical and functional orientations (Reijers, 2006). There is a strong link between non-financial performance and business process orientation, which is indirectly linked to increased financial performance (Škrinjar, Bosilj-Vukšić and Indihar-Štemberger, 2008).

There are plentiful reasons as to why process oriented businesses are common in large organizational contexts. One of the larger reasons is due to the fact that most firms in modern times find large improvement opportunities in the interfaces between different units, divisions, and functions. Some common advantages to employing process orientation are (Sörqvist, 2004):

- Achieve a comprehensive impression of employees’ work
- Improved customer focus
- Improved improvement capability
- Increased change stability
- Possibility to simplify complex organizations
- Facilitates learning from and comparing to other activities and parties
- Requires good leadership

The process-focused organization has empirical support of delivering better results due to improved customer satisfaction (Frei et al., 1999). Since customer satisfaction is commonly referred to as a direct contributor to market value and returns, process orientation is a certain business improvement element (Reijers, 2006). In addition, the size of an organization plays a large role in how customer satisfaction is created. Small firms tend to be more reliant on their few employees, since each and every one of them contribute to a higher percentage of their firm’s results, therefore have very flexible and customized ways of dealing with their customers individually based on the preference of each employee. By comparison, large firms have better customer complaints management processes (Gustafsson et al., 2003). However, customer satisfaction is different from customer value delivered. Value is a more powerful measurement of performance than satisfaction since the latter is an emotional response to the perception of received value and therefore a measure of perceptions about past value delivered. This means that an unsatisfactory event has to take place before it can be measured. If value is instead measured, future satisfaction is measured (Gardner, 2004).

Non-Value Adding Work

There are a few concepts associated with process work: time, value contribution, and variation (Gardner, 2004). When a process is studied in-depth, for instance by using Value Stream Mapping (VSM) where every sub-process, activity, and task belonging to a process, a significant amount of time us usually found to be non-value creating, i.e. waste. This waste usually comes from one of the concepts.

It is sometimes useful to classify the importance of activities involved in a process. While the process time spent on a work object may be active rather than passive, not all work is creating value. There are three different degrees of value creating activities: Value Adding (VA), Necessary but Non-Value Adding (NNVA), and Non-Value Adding (NVA), or waste work (Hines and Rich, 1997).

\[
 t_{\text{process}} = \sum t_{\text{VA}} + \sum t_{\text{NNVA}} + \sum t_{\text{NVA}}
\]

NNVA is work that is required for the value adding work and is sometimes difficult to identify but commonly includes the following activities: maintaining control, performing checks, and coordinating work (Gardner, 2004). Since NNVA is required removing that kind of activity is difficult and usually means that the process needs to be reengineered from the ground up. However, NVA activities can under normal circumstances be done away with without any repercussions for the process.

Variation is a challenge for a process since it threatens the standardization aspect that is inherent to processes in general, as a process is usually defined as something
that is repeated. There are two types of causes of variation, common and special. Common cause variation is a natural part of any process and can be predicted to create results within a certain range. Common causes can normally be identified but elimination of them have little effect on the end result of the process (Sörqvist, 2004). Special cause variation is driven by external or intermittent events that disrupt the process in various ways. These events are not natural part of a process and create unpredictable results which can drive the process out of control (Gardner, 2004).

**Process Knowledge**

Understanding of processes is directly correlated with their performance and improvement potential. While no process will ever reach any sort of perfection, nor do any operate in total ignorance, there is a lot to be gained from moving towards perfection (Slack and Lewis, 2011). It is between these extremes that the potential for improvement exists, where managers try to optimize and improve in order to maintain or improve process performance.

A process has inputs \( x = [x_1, x_2, \ldots, x_n] \) and outputs \( y = [y_1, y_2, \ldots, y_n] \), and the output is a function of the inputs:

\[
y = f(x)
\]

Having process knowledge means that this function of inputs is understood and any alterations to the function can be foreseen, measured, and controlled. Bohn (1994) presents an eight-step scale for assessing process knowledge ranging from ‘complete ignorance’ through different measurement and assessment stages to ‘complete knowledge’.

**Stage 1: Complete ignorance**

Nobody in the process knows what the process entails, or what the meaning of having processes is. Any noticed or unnoticed phenomenon is disregarded as a random disturbance to the process’s output.

**Stage 2: Awareness**

The process’s existence is known and its relevance might be recognized. It is not possible to use this knowledge in the process, but it can be investigated in order to get to the next stage. Moving from stage to stage is often done through serendipity, by making analogies to unrelated process or by using knowledge from outside the organization.

**Stage 3: Measurement**

Like the previous stage, there is knowledge of the existence of a significant process that can be measured with some effort, but not controlled. However, despite the fact that it cannot be controlled, the process can be changed to accommodate exploitation of the uncontrollable effects.

**Stage 4: Control of the mean**

At this stage, the control is possible, but at a crude level. In other words, there
is knowledge of how to control the mean bringing about some stabilization to
the process. Previously exogenously viewed variables can now be manipulated
as control variables. This stage also facilitates easier further process learning,
since controlled experiments can now be performed.

**Stage 5: Process capability**
This process refers to the control of the variance. At the previous level only
the mean could be controlled, but now the range, or the different disturbances
that affect the input, can be controlled as well. That is, knowledge of the input
\( x \) is a process in itself and is now recognized. This means that there is no
need to ‘reinvent’ the wheel when activities are repeated.

**Stage 6: Know-how**
Process characterization, or know-how, entails that managers know how vari-
ables affect the output when changes to the variable are made. This means
that the process can now be fine-tuned and optimized and feedback control
can be implemented to further increase the quality of the output through
providing useful information for improvement.

**Stage 7: Know-why**
At the know-why stage, the process knowledge is on a scientific level with non-
linear and interaction effects with other variables. At this stage, optimization
can now take place with a high effectiveness due to the knowledge of said
interaction effects.

**Stage 8: Complete knowledge**
This stage is not reachable in practice, as it means that all possible variables
are known and how they are related and interact. There is an exact expression
for \( y = f(x) \) meaning all inputs and outputs are known and feed-forward
control can be practiced.

**Barriers to Process Improvement**

An organizational process can be improved in various ways. Most improvements to
processes are very small, but improvements nonetheless. Other improvements are
very large, such as completely overhauling an existing process. These two types
of improvements can be referred to as continuous improvement and breakthrough
improvement (Slack and Lewis, 2011). The former is also known as *kaizen* and
such initiatives can range in scope and structure from unstructured small changes
to scheduled improvement meetings involving the entire organization (Angelis and
Fernandes, 2012). Breakthrough improvement is based on innovation and concerns
improvements that dramatically changes the way in which an operation works.
(Slack and Lewis, 2011).

Process improvement is not always straight forward and easily implementable.
There are various barriers in processes which have been identified as hindrances
to the development of better practices. These barriers need to be identified and
dealt with in order to achieve the goal of improvement activities (Huq, 2005) and they are presented below in Table 4.

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inappropriate Culture</td>
<td>General culture blame, lack of empowerment culture, organizational philosophy</td>
</tr>
<tr>
<td>Lack of customer focus</td>
<td>Inward looking, not listening to customers</td>
</tr>
<tr>
<td>Lack of resources</td>
<td>Lack of people, money, or time</td>
</tr>
<tr>
<td>Management issues</td>
<td>Poor planning, prioritization, lack of support, failure to change, bad internal communication and coordination</td>
</tr>
<tr>
<td>People issues</td>
<td>Lack of training, low knowledge, limited empowerment</td>
</tr>
<tr>
<td>Poor processes</td>
<td>Bad process design, poor implementation, inappropriate processes, lack of standards</td>
</tr>
</tbody>
</table>

Table 4  The barriers to internal service process improvement and their definitions. Adapted from Johnston (2008).

Of the barriers presented in Table 4, the most commonly cited ones can be found to fit in ‘Lack of customer focus’ and ‘Poor processes’ (Johnston, 2008). Any improvement activities aimed at a process where one or more of these barriers exist run the risk of falling short of their objective, especially if they are off-the-shelf type improvements with limited customization to the organizational context (Huq, 2005). What this means is that unless the hindrances to process improvement are known, the approach to carry out any development measures can fail to reach the expected boost to the process’s performance.

3.2  Lean and Internal Service

In their well-cited work The machine that changed the world Womack, Jones and Roos (1990) laid out the foundation for present day’s most widely promoted manufacturing mindset. Their book presented the The Toyota Production System which became known as lean manufacturing. The essence of the lean philosophy is to take the customer’s perspective and eliminate anything that is, or contributes to, waste or wasteful activities. Initially, this was developed to involve five key principles: specify value, identify value streams, make value flow, customer pull, perfection pursuit (Womack and Jones, 1996). This was described as ‘lean thinking’ in order to separate philosophy from practical applications, the former being lacking from early adopters which caused performance of the latter to fall short of the expectations (Hines et al., 2004). In other words, adopters of the promising improvement scheme failed to see the importance of adopting the lean mindset and therefore applied lean manufacturing to a system where the contextual conditions did not match those of the lean paradigm.

Lean thinking came from the idea of a lean enterprise where all its functions, e.g. design, procurement, sales, marketing, quality assurance, and manufacturing, have
work processes and communication channels that are designed to remove all waste-
ful activities (Womack and Jones, 1994). Although the focus of lean has been on
manufacturing with 75% of scientific articles about lean is focused on it (Wei, 2009)
today’s service heavy-economy with, for instance, 80% of the U.S. economy repre-
sented by services. Therefore, there is a separate but similar application of lean on
services referred to as lean service. In essence, lean service applies a manufacturing
view on a service and identifies wasteful activities just like in manufacturing. There
is some criticism to this idea, since it can be argued that the the difference between
service and manufacturing is too large the applicability of lean manufacturing on
services is very limited (Seddon et al., 2011). Since the CAR process is classified
as an internal service, this section talks about the characteristics of such processes
and how to make them lean.

Internal service and lean service are thoroughly researched and provide great tools
to make intra-company improvements. Johnston (2008) outlines the barriers of
services and how they affect the perceptions of the service value to the employees,
the main implication of which is that the bi-directionality of internal services often
carries with it a delusion of provision. This delusion makes people think that what
they deliver is better than what they receive, which obstructs the improvement
process since people think that they are not the ones that need to improve. In
the case of internal services, Maleyeff (2006) infers that the main deliverable is
information and that cross-functional cooperation is required, while internal services
are rarely seen neither as of high value nor urgent. However, Suárez-Barraza et al.
(2012) indicate that there is no clear distinction of what lean service means in
practice, since services can be entirely context driven. This means that what is
lean internal service in one process, not necessarily translates to a different internal
service process. The implication of this is that lean internal service in one type of
process may not directly be able to be applied to another, making a generalized
lean internal service concept difficult.

Internal Service Characteristics

Internal services differ from many other types of processes and have some structural
similarities (Maleyeff, 2006): task variability, process flows through multiple func-
tions, lots of information exchanges, many reviews by managers or experts, costs
and benefits are hidden, no explicit incentive for urgency, and difficulties to stream-
line to all involved parties. Firstly an internal service is always about information
exchange and the quality of it. As a result of information being the most important
deliverable there is usually a high degree of focus on what medium the information
is delivered in or on how the information is shared. This is a more direct adaption of
how lean manufacturing work in a production process, and a better idea for internal
service systems is instead to focus the attention on the information itself, how it is
formatted or the quality of it in general.

Separate from what processes that start and end with external customers entail,
such as manufacturing where a raw material is transformed into a product, internal
services usually have high variability. This can manifest itself both in terms of processing times as well as variability in what the service should deliver (Maleyeff, 2006). This means that standard lean manufacturing components such as ‘takt time’, where production is set to keep a certain rhythm, is incompatible with internal services. Instead, a lean service should exploit the advantages of an employee, e.g. flexibility, intelligence, and experience.

In any usual internal service there are numerous business functions involved (Johnston, 2008). For instance, financial service might collect information from the sales, legal, and marketing functions in order to analyze investments. As a result of the many involved functions, improvements to the process require a cross-functional team of people to make any measurable improvements to the process. This makes for a great possibility to use a Kaizen methodology to make changes to the process with the support of top management to make any changes the Kaizen team sees a need for.

Information exchange and management reviews both pose risks of waste in a process. For one, any extra step in a process is usually considered as waste, but handoffs of information also risks distorting the data due to differences in interpretation. On top of that, management or technical reviews, such as quality approvals or accuracy checks, are extra costs and a possible bottleneck activity. One of the components of lean manufacturing is empowerment (Suárez-Barraza et al., 2012) and therefore review activities are not appropriate parts of a lean process.

Since most internal service processes are not paid for explicitly and usually produce intangible outputs while value to customers is multidimensional (Maleyeff, 2006). For instance, the value of a document created by an internal service process is not only valued at what is in the document, but also in the communication between colleagues for troubleshooting and mutual learning. On top of that, costs are usually only shown as overhead, therefore they are hidden from detailed executive oversight and only visible when looked at as a whole.

As a further structural implication of the way internal service processes work, there is rarely an outspoken feeling of urgency even when it is needed by the internal customer (Maleyeff, 2006). This can be attributed to the fact that people in the the process are unaware of how the same process affects other people that are part of it. Usually, a simple, but thorough and realistic, process flow map can be appreciated by the individuals in the process, since the designed process map usually indicates an ideal state, while the real process looks and behaves differently due to local contingencies (Bonaccorsi et al., 2011). Lean manufacturing in a factory setting usually deals with creating a motivator for urgency by setting up visual displays – either physical or on a computer screen – that enables everyone to see the status of all activities in a process, and that way people can see the relative priority of tasks that need their attention (Maleyeff, 2006).

Last, and an important aspect of contingency theory, is the issue of having a one-size-fits-all mindset when it comes to these internal services. As a result of the variability of tasks in a process of this kind, along with the cross-functionality and
other structures listed in this section, a contingency element in the design of internal service processes is required (Maleyeff, 2006). Contingency theory maintains that a process needs to take local dependencies into account in order to achieve what the process’s objectives are, and these dependencies can differ depending on which functional unit performs the process (Sousa and Voss, 2008).

**Lean Thinking**

The manufacturing discipline of make-to-stock changed the way things are done with the entrance of Japanese make-to-order and superior management as studied in the Toyota Corporation in the 1980s when it was seen that the Japanese company outperformed their Western counterparts by twice the productivity and had a hundred times less quality defects (Piercy and Rich, 2009). This production system was referred to as “lean production” (Womack et al., 1990) and builds on five principles that would be employed when undergoing a lean transformation (Womack and Jones, 1996):

1. **Value.** Identifying what customers need.
2. **The value stream.** A visual representation of how value is added and delivered, and then used to find wasteful activities.
3. **Flow.** Strive for awareness in how the value stream works, and ensure a seamless flow.
4. **Pull.** Only deliver what is demanded instead of having buffers and stocks.
5. **Perfection.** Keep improving the processes and strive for a perfect process.

Lean practices have always been primarily about reducing waste (Womack et al., 1990). Since the ideal state is perfection it is by definition unreachable, however that does not mean that there is a reason to stop trying to achieve it. As mentioned in Section 3.1 there are three types of activities in a process: Value Adding (VA), Non-Value Adding (NVA), and Necessary but Non-Value Adding (NNVA). In a lean service process there are said to be seven categories of NVA activities (Maleyeff, 2006):

- **Delays.** Items in queues or waiting to be transmitted.
- **Mistakes.** Errors that cause redoing work, or quality concerns.
- **Reviews.** Checking work for correctness or quality level.
- **Movements.** Physical transport of people or documents.
- **Duplication.** Activities performed more than once or by the wrong party.
- **Processing inefficiencies.** Ineffective use of process resources.
- **Resource inefficiencies.** Wasting the available resources.
All of these listed categories of waste add no value to a customer and are therefore agents of unnecessary costs. Employing these seven design steps has been shown to improve service processes in terms of cost, quality, and lead time (Swank, 2003).

Making an Internal Service Process Lean

What it is that makes a process lean is not something that is easy to define other than reducing the different kinds of waste. However, there are some practical steps to take in order to improve a process. As mentioned before, the main objective of lean thinking is to find what the customer values and remove whatever activities that do not contribute to that. To achieve reduced waste in a service process it is important to standardize procedures, remove process loop-backs, evening out task burdens, segregating complexity, and posting performance results (Swank, 2003). Procedure standardization refers to having some work pattern to follow even though the work itself varies, such as making sure that other people can take over work started by others if necessary. Loop-backs are essentially reviews and should not be necessary in a lean process because of the added benefit of empowerment (Suárez-Barraza et al., 2012). Evening out work entails making sure that there is an even distribution of work between people who have the competence to perform it. Combined with complexity segregation, i.e. categorizing work according to priority and resource need, work distribution should strive to have no underworked or overworked individuals (Swank, 2003). Lastly, displaying how a process is doing and what is needed can add an element of urgency while facilitating knowledge of what the internal process customer needs to do their job (Maleyeff, 2006).

There is a great opportunity to seize from combining the operations, internal-focused side with the service, customer-focused side to achieve a better grasp of the intricacies that involve the two when combined (Johnston, 2008). From an internal service perspective, such an initiative can provide both customer and internal efficiency at the same time. However in practice, one or the other is usually prevailing. In a study on New Public Management in the United Kingdom government it was suggested that too much customer focus compromises the process focus (Radnor and Johnston, 2012). Basically, the effectiveness of a process can impact the efficiency of the process negatively. Therefore there is an improvement cycle in service processes where the focus on the customer reduces the efficiency of the process, and when the efficiency is improved the effectiveness lags behind in turn, see Figure 5 for a representation. There are two drivers in this context: the market and the efficiency. Efficiency looks towards reducing costs within a process for the sake of returns to shareholders and the market driver refers to understanding the customer’s needs.
Continuous Improvement

Continuous Improvement (CI), also known as Kaizen, is a company-wide initiative to improve process performance, product or service quality Schweitzer and Aurich (2010). It is a key to sustained competitive advantage and an important component in lean thinking, TQM and Six Sigma (Angelis and Fernandes, 2012; Womack et al., 1990). Sprung from the Japanese Toyota Production System, later to be called lean production, where the workers would have weekly meetings to improve their work, along with statistical quality control and Walter A. Stewhart’s Plan-Do-Check-Act (PDCA) that surfaced in the 1920s, CI is a step-by-step method for process development to increase productivity (Zangwill and Kantor, 1998).

Checklists

In general, most improvement methods are somewhat associated with tasks that are repeated continuously. While proactive improvements are generally to be preferred due to the fact that they minimize costs, eliminate of effects, and create competitive advantage, reactive improvements are more common (Sörqvist, 2004). This is a
fairly simple idea, and it has been shown to apply even for complex processes (Slack and Lewis, 2011).

Gawande (2010) reminds readers that checklists have high value in many professional areas, such as aviation, law, and health care. Most interestingly, he recounts the initiative to have nurses in a hospital critical care unit observe that medical teams took all the five steps that are suggested to be taken to reduce infections from the use of intravenous central lines. It turned out that the medical teams missed one or more steps about a third of the time. Therefore nurses were empowered to have the authority to stop a procedure if one or more steps were missed, and ask the doctors if the central lines should be reviewed. This made the way for checklists in this complex operating setting.

Complex processes, often sinking under the weights of facts, are sometimes seen as in need of complex improvement schemes to reach any kind of performance increase. However, a simple process like checklists can greatly reduce errors and refittings and should not be disregarded as unfit tools when a process has a high degree of complexity.

3.3 Failure Reporting, Analysis, and Corrective Action System

Reliability is one of the main quality performance dimensions (Forker, 1997) and can be defined as the ability of a component or system to perform according to requirements for a specific period of time (Lee et al., 2010). FRACAS is a management tool with the purpose of identifying and correcting shortcomings in order to prevent recurrence (U.S. Dept of Defense, 1998), providing historical data for statistical analysis (Lee et al., 2010) and ultimately increase quality and performance. This forms a closed loop with improvements introduced in every iteration, see Figure 7.
The use of FRACAS is quite common throughout many industries, examples include military, railway, nuclear power, and the semiconductor industries (U.S. Dept of Defense, 1998; Villacourt, 1992; Lee et al., 2010). However, the full potential of FRACAS – improving quality and productivity while reducing costs – is rarely achieved due to three main areas (Hallquist and Schick, 2004):

- Complex organization interaction
- Inefficient and ineffective data tracking
- Absence of of goals with prioritization

Involvement in FRACAS spans many different parts – both people and miscellaneous constructs – such as engineers, equipment, documents, product specifications and organizations. These aspects are the main contributors to the above listed problem areas. (Lee et al., 2010). Moreover, FRACAS is a closed-loop system and therefore all data passes along to all stakeholders. Ensuring that the data is retrieved efficiently and root cause analysis effectively and continuously improve...
performance, a Failure Review Board (FRB) works as the closing link in the closed-loop system. The FRB feeds the analyzed information back to the originating function where it forms the basis for improvement activities. The FRACAS closed-loop system works thanks to the fact that it involves both the customer and the supplier throughout the process (Villacourt, 1992).

**Ideal Versus Real World Process**

There are a few differences between an ideal system and a real one. Ideally, the data retrieved for analysis in FRACAS is correct and accurate, consistently formatted, and covers all necessary items for inspection, e.g. part and serial number, references numbers, operational hours, time to failure, location, description of failure, environmental conditions, troubleshooting details, root cause, interim corrective actions, identification of systemic issues discovered during repair, and repair cost and time. If all of that data is available for analysis in a well formatted way, there would be little problem creating FRACAS reports outlining the failure rate, time between failures, and time to repair. This data would then be of great use for engineering changes to improve performance (Cieman, 2008) along the lines of what can be seen in Figure 8.

![Failure data flow diagram](image)

**Figure 8** A representation of one iteration of how the FRACAS process deals with a recorded failure and the objective.

In reality, a number of complications arise in a FRACAS process. For one, the failure data collection can have a large quality range as different people collect the data. The reported failure could be observed and reported by, for example, the user, service personnel, depot personnel, or OEM repair personnel, all with different processes for collecting and reporting failure data (Cieman, 2008). This data is then typically entered into a database that follows the FRACAS requirements of such a database. Ideally, this database also requires a certain decided upon level of detail and minimum required filled out data fields, all of which are in place to facilitate efficient and effective problem resolution by eliminating unnecessary information and demanding useful details (Hallquist and Schick, 2004).
Complex Organization Interaction

As with many administrative processes, communication and interaction can be a limitation in terms of efficiency and effectiveness as complex rules for communication channels are formed. Since FRACAS is a closed-loop system, the information contained in the system is contributed by and made available to many different business functions in order to be effective. These functions are:

- Manufacturing
- Operations
- Sales and marketing
- Testing
- Failure Review Board
- Engineering
- Quality Assurance
- Customer Service
- Suppliers

Some of these listed functions may also require to be included at multiple points in the FRACAS process. Because of this, and all of the different functions involved in the process, communication and interaction can become quite complex which can cause delays the resolution time (Hallquist and Schick, 2004).

Lack of Prioritized Goals

Depending on the size of a project or program, the size of a FRACAS scheme differs (Ciemian, 2008), and that size has a direct correlation with how much time and effort is allotted to designing a scheme. Usually, there are three main reasons for implementing FRACAS:

1. Meeting customer requirements
2. Improving internal reliability
3. Improving the next generation of products

Depending on what function in an organization is responsible for developing a FRACAS scheme, these three reasons are valued differently. Because of resource constraints, fully developed schemes are usually not used in favor of using software that is already in use in the organization, such as Microsoft Excel or Access based databases. In the common case, the FRACAS development ends here resulting in low efficiency and poor cohesiveness (Hallquist and Schick, 2004). Much depending on the fact that FRACAS is an internal service system, people generally do not recognize the value and need of the initiative until much later in the life of the
program (Johnston, 2008). This affects this specific internal service process on the planning stage as insufficient resources and attention is given to the development at the proper time (Hallquist and Schick, 2004). On the management level, the vision is to have a FRACAS initiative reduce the total number of quality issues throughout the organization. For managers, the initiative is meant to reduce the costs of warranties given to customers, as well as yield reliability trends and other items for analysis.

These three different levels of expectations are not linked and in the common case they are not discussed and given priorities. This causes insufficient finances to require a cheap implementation while a lot of data input is expected while implementing too late in the project lifetime. To overcome these problems there should be a FRACAS board whose purpose is to assign the different goals of the process with priorities and implement it thereafter (Hallquist and Schick, 2004).

Ineffective and Inefficient Data Tracking

For a FRACAS initiative to gather useful data, the amount of data to input into the system needs to be on a reasonable level. Not unusually, there are over 80 fields of data input when a failure is recorded (Hallquist and Schick, 2004). While that data may well be useful, the task of inputting it all causes many fields to be skipped and therefore the data will be incomplete. When a task requires more effort or time than what an individual can bother with, the task will not be carried out fully or skipped completely (Emiliani, 1998). In terms of FRACAS schemes, this means that if too much data or the way the data is entered into the database can be too time-consuming to carry out the task, resulting in a scheme that does not collect useful data.

3.4 Summary

This section has presented the theoretical concepts that were used in the study. Most importantly, internal services have many similar characteristics and therefore also barriers to performance improvements (Maleyeff, 2006; Johnston, 2008). However, these service processes’ performance can be improved by applying the concept of lean service, similar to lean production, by removing unnecessary activities (Swank, 2003; Suárez-Barraza et al., 2012; Radnor and Johnston, 2012). FRACAS is an internal service process that exhibits many of the characteristics that make up internal services, however in the case for this study, the CAR process involves external parties to a limited extent. Regardless, it can be viewed as an internal service to a large extent, since the majority of the process takes place within the organization and the involvement of external parties is limited to the input of data.
4 Current Process

This section describes what the current process looks like and how it performs. The structure of this section is the repeated in Sections 5 and 6 and that structure is beginning at the inputs to the process, then the process itself, and finally the process’s output.

Typically, when a customer finds a nonconformity on delivered goods from ENGINEERING CORP, they file a Nonconformance Report (NCR). A CAR is generated by an administrator, or CAR Owner (CO), at ENGINEERING CORP as a result of that customer’s NCR. This means that only quality defects after shipping are considered for CARs, i.e. during a customer’s receiving inspection, manufacturing, testing, and commissioning. Faults found before shipping are not part of the CAR process.

The intended resulting output of a CAR is that the error that caused the nonconformance is permanently prevented from recurring through three steps:

- a root cause analysis,
- containment of the fault by inspection of all other identical parts,
- and finally a corrective action implementation plan.

A CAR document has a few relevant fields to be filled out. First of all, the cause of the nonconformance is filled out (e.g. supplier, engineering, manufacturing, or project management). Next is a field that is used for immediate action to contain the problem, e.g. “sent replacement equipment” or “repaired on site”. This is also the section used for containment action as mentioned above. In order to eliminate the problem from recurring there is a field to describe the root cause and then a field describing corrective actions and the implementation of them.

There are two main functional units worth mentioning in this study: Project Quality Assurance (PQA) and Supplier Quality Assurance (SQA). They are both key stakeholders in the CAR process and in the study itself. The limitations of this is presented in the Limitations subsection in Section 2.2. The PQA Managers make up the supporting role in the project core team and, as the name entails, ensure that project quality requirements are upheld. This means that when a customer reports a nonconformity, it is the PQA Manager who is their contact in the project core team and therefore the one who is most dependent on the CAR results. It is this function that called for this study to be conducted. The SQA unit is a line organization and work in several projects at the same time. The responsibilities of the department are Parts Approval Process (PAP), CAR, Supplier Evaluation and Approval Process (SEAP), and supplier development. Currently, the PAP responsibilities take lots of time due to the travel associated with it, and therefore there is simply not enough resources or time to handle CARs. It is the SQA function that handles CARs that are labeled as caused by ‘Supplier’.
4.1 Input

When a customer finds a product delivered by ENGINEERING CORP that is not compliant with the quality agreements, they start the warranty complaint process by drafting an NCR. This report can be prepared by people in numerous roles depending on which customer and site is concerned. The report contains any information the drafter finds important for the claim except for if it is an Engineering Controls Department device, which has a thorough checklist for what information needs to be included in the NCR for a swift problem resolution. In the case for complaints handled by the SQA function, which handles numerous components delivered by almost as many suppliers, there are no requirements from the SQA function.

Creating the Corrective Action Request

The next step for the nonconformance complaint is to be processed by a Warranty Customer Coordinator (WCC) on the site, if it is an internal customer, or at the headquarters if it is an external customer. This administrator then sets up the CAR in the database by filling out the required fields, e.g. what component is affected, batch number, symptoms observed and any other information provided by the NCR, as well as the nonconformance cause which usually depends on the component. If it is a component not designed or manufactured by ENGINEERING CORP itself, but rather by a supplier, the nonconformance cause is set to ‘Supplier’, which is the function this study is focused on. As the CAR is created, the WCC becomes the CO for it. In the special case when the nonconformance cause is ‘Supplier’, the WCC also sends a claim to the supplier that the faulty material to ENGINEERING CORP.

If the CO deems the NCR insufficient or does not fill all of the criteria on the Communication and Controls Department’s checklist, more information is requested immediately and the CAR status is set to ‘Pending Nonconformance (NC) Info Update’. This status is then updated to ‘Open’ once sufficient information is available and assigned to the responsible CAR Manager (CM). In the cases where the customer performs a repair on the affected component a repair report is required to be attached to the CAR and the status is instead set to ‘Pending Repair Report’. Other instances require the affected component to be sent to an ENGINEERING CORP site for investigation and repair, if the CO or customer thinks it is necessary, which means the status should be set to ‘Pending Material’ while the component is in transit.

<table>
<thead>
<tr>
<th>Event</th>
<th>Current status</th>
<th>Action</th>
<th>New status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive new NCR</td>
<td>None</td>
<td>Create CAR, and if needed, request more NC info, repair report, or request material</td>
<td>Open</td>
</tr>
</tbody>
</table>

Table 5  Instruction for COs when receiving a new CAR.
The Role of the Corrective Action Request Manager

The next step in the preparation of the CAR input is to change the status of it to ‘Open’. This status change is what moves the CAR to the user interface of a CM, as well as activates the 28 days within which the case should be resolved. This status change also causes the the CAR to disappear from the CO’s user interface view in the database as responsibility for the CAR is transferred to the CM at the ‘Nonconformance cause’ unit. In turn, the CM reviews the CAR that have just appeared in their database view to see who in the unit is suitable to resolve the issue. The CM then selects that person by putting their name in as CAR and changes the status to ‘On-going’ which transfers the responsibility to to the CAR Resolver (CR) and therefore also the case itself is moved to their user interface view in the database, removing it from the CM’s view. In the event that the CM sees that a CAR is not related to their unit, they change the CM so that the case is transferred to the correct unit and keeping it in the ‘Open’ status.

<table>
<thead>
<tr>
<th>Event</th>
<th>Current status</th>
<th>Action</th>
<th>New status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive new CAR from CO</td>
<td>Open</td>
<td>If assigned to correct function, assign to a CR</td>
<td>On-going</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If assigned to incorrect function, reassign to correct CM</td>
<td>No change</td>
</tr>
</tbody>
</table>

Table 6  Instruction for CMs when receiving a new CAR.

4.2 Process

When an employee receives a CAR from their manager they become the CR for the case in question. Anyone who acts as a CR also has other responsibilities that take up more of their time. In the case of the SQA function, the employees spend most of their time assessing new suppliers’ quality criteria in the SEAP or specific parts in the PAP, as well as other related activities. This means that being a CR is just one of the many components of an SQA employee’s work responsibilities.

The CO initially checks to see that the nonconformance report is complete enough to create a CAR, otherwise the nonconformance report is sent back to the issuer for clarification. If the report is clear the CO will set up a CAR and depending on what department is concerned also assign a CM who, in turn, assigns a CR with knowledge to investigate the request in accordance with the intended output and has the time to do it. If the CR needs more information about the nonconformance claim, the CO is informed and they then take action to receive more information about the case, or requests to have the equipment transported to ENGINEERING CORP for investigation. When the CR is done investigating the request, it is sent to the CM to be approved. If it is rejected the case comes back to the CR for improvement, and if it is accepted the CO communicates the CAR result to the customer who then has 28 days to accept or reject it, after which time the case is
closed. See the flowchart in Figure 9 for a summarizing representation of the CAR process.

![Flowchart of the CAR process](image)

**Figure 9** This flowchart represents what the CAR process looks like in a simplified form. The dashed lines represent necessity-based activity.

The process goes through a number of stages, each of which denotes a CAR’s status. When a CAR is created its status begins set as ‘Open’. Later, when it has been allocated to a CR the status changes to ‘On-going’. If there is something wrong with the case, more information is needed, or if the material needs to be examined more closely, the status is changed to ‘Pending more information’, ‘Pending NC info update’, or ‘Pending material’ until the request for whichever of those three is fulfilled, by which time the status is changed back to ‘On-going’. When the investigation and root cause analysis, containment action, and implementation plan are complete the case is forwarded to the CM with the status ‘Investigation ready’. The CM then either rejects or accepts the investigation as mentioned before, and the status is changed to ‘Investigation approved’ or back to ‘On-going’. If it is approved, the CO communicates the results of the investigation to the customer and sets the status to ‘Communicated’, after which the case gets set to ‘Closed’ if the investigation is not rejected by the customer.

**Resolving the Case**

Clicking on their name in the CAR database shows a CR which cases currently require their attention, i.e. have the status ‘On-going’ and are assigned to them by the CM. Before starting to work in a resolution, the CR makes sure that there is enough information in the case file, such as in form of an NCR, photographs, or a repair report from either the customer or ENGINEERING CORP. Should there be a need for more information or to send the material to ENGINEERING CORP for investigation, the CR changes the status of the CAR to one of the three ‘Pending NC Info Update’, ‘Pending Repair Report’, or ‘Pending Material’. This status change transfers the CAR back to the CO who regains the responsibility for the case until the requested information or material has been received and can change the status back to ‘On-going’.

A CAR is considered resolved when these three items are answered:

- Containment: What was done to make sure that no other components have the same issue
- Root cause identification: Find what the underlying issue to the fault is
• Corrective action: What will be done to ensure that the same problem does not recur, and how to implement the corrective action.

Since the SQA function works exclusively with external suppliers, any problem resolution involves an external party. When a supplier has received a claim from the CO at the time of the CAR creation it can start its own investigation which then can serve as input for the CR at SQA.

When the investigation has been completed and the containment, root cause identification, and corrective action have all been done, each of which represented by a text field on the CAR document, the CR changes the status from ‘On-going’ to ‘Investigation Ready’ which transfers the case file from their user interface view to that of the CM.

<table>
<thead>
<tr>
<th>Event</th>
<th>Current status</th>
<th>Action</th>
<th>New status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive CAR from CM</td>
<td>On-going</td>
<td>If not assigned to correct CR, inform CM</td>
<td>Open</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If CAR info is sufficient, start investigation</td>
<td>No change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If NC info is insufficient, request additional</td>
<td>Pending NC Info</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If a repair report is needed, request one</td>
<td>Pending Repair Report</td>
</tr>
<tr>
<td>Investigation completed</td>
<td>On-going</td>
<td>Fill out required CAR fields</td>
<td>Investigation Ready</td>
</tr>
</tbody>
</table>

Table 7  Instruction for CRs when receiving a new CAR.

Repeated Faults

There are some faults that come in but are already having their root cause under investigation, or the implementation is large in scale and therefore takes a long time to implement. This means that there will still be CARs coming in, but that are already either under investigation already, resolved but not corrected yet, or involving many parts with the same root cause. Since there will be one CAR case file each and every one of these faults, the CRs’ list can become filled with – to them – the same problem.

When repeated faults exist, it is the responsibility of either the CM or the CR to link any on-going CARs that exist. This is possible to do in the a certain field on the form which is an issue identifier. After a CAR has been resolved, the CR can notify the CO of the solved issue and it is then their job to close the linked cases. Furthermore, if a new CAR case comes in and the issue has already been resolved, the case can be immediately closed without further investigation.
4.3 Output

The CAR process is modeled after the FRACAS and as such it is meant to contribute to CI in the overall quality of ENGINEERING CORP’s products. In order to do that, data needs to be collected and analyzed to see the effects of any attempts to make improvements. For the customer the CAR report is meant to work as reliability assurance in the way that when they have a subpar quality product they will have written assurance that their supplier is taking the claim seriously and have taken action towards not repeating the issue.

Approving the Investigation and Informing the Customer

It is the CM’s job to approve an investigation completed by a CR. The finished CAR investigation reappears in the CM’s view once the CR change the status of it to ‘Investigation Ready’. It is then the CM’s job to review the document to make sure it is useful and of sufficient quality in terms of informativeness, understandability, completeness, and relevant. If the CAR does not meet these criteria according to the CM’s discretion, the status is set back to ‘On-going’ thereby rejecting the investigation. If all of the criteria are fulfilled the investigation is accepted the CM changes the status of the case to ‘Investigation Approved’ which transfers the case back to the CO’s database view. It is very rare for the CM to reject an investigation (CR1).

The last two steps in the process is to communicate the result of the problem resolution to the customer, and have the customer provide feedback on the received CAR. When the approved investigation returns to the CO’s user interface view, their job is to communicate the results of the investigation to the customer, and thereby change the status of the CAR to ‘Communicated’. This status change means that the customer has 28 days to give feedback on the investigation and request it to be reopened in the event that they are not satisfied by the results, or approve it if they accept it. If the customer does not provide feedback, the case is closed after 28 days, i.e. the status is set to ‘Closed’.

<table>
<thead>
<tr>
<th>Event</th>
<th>Current status</th>
<th>Action</th>
<th>New status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive approved CAR</td>
<td>Investigation Approved</td>
<td>Notify the customer by sending the completed CAR document</td>
<td>Communicated</td>
</tr>
<tr>
<td>Receive feedback from customer</td>
<td>Communicated</td>
<td>If the customer approves the investigation, close the case</td>
<td>Closed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If the customer rejects the investigation, return it to the CM</td>
<td>Open</td>
</tr>
</tbody>
</table>

**Table 8** *Instruction for COs when receiving an approved CAR and feedback from the customer.*
Using the Data from the Process

In order to track the quality of on-going projects, for which they are responsible, the PQA employees use the CAR database output and analyses in their work. Moreover, since they are the point of contact for quality concerns that customers might have, they are dependent on accurate information in the database in order to communicate the progress to interested customers. Secondly, in order to achieve improved quality in all processes, the output needs to be accurate and timely for any analysis to be fruitful. Since the CAR process is a FRACAS process, the closed loop system builds a ‘lessons learned’ knowledge bank for process improvement initiatives.

It is these two items that make up the objectives of the whole CAR process. It is evident that all parties benefit from the process’s objectives, the customers continuously see higher quality as time progresses and ENGINEERING CORP creates knowledge for itself in how to improve processes and product quality to attract and retain customers. But, as the following section will present, the process has some limitations when it comes to CAR in the SQA function, which inhibit the process from working as intended.

To illustrate how the ownership changes throughout the course of the CAR process see Table 9 where each row represents a new step in the process. The frequent changes of ownership is apparent here and the different statuses progression is clear. The table should be interpreted in the way that the status on each row is in the column of the CAR role that can see the case in their database view.
<table>
<thead>
<tr>
<th>Step</th>
<th>CAR Owner</th>
<th>CAR Manager</th>
<th>CAR Resolver</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Receive NCR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Open</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>On-going</td>
</tr>
<tr>
<td>(3a)</td>
<td>Pending NC Info</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3b)</td>
<td>Update</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3c)</td>
<td>Pending Repair</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3d)</td>
<td>Pending Material</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>On-going</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Investigation Ready</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Investigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Approved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Communicated</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Closed</td>
<td></td>
</tr>
</tbody>
</table>

**Table 9**  From top to bottom: a representation of how the ownership and responsibility for a CAR changes throughout its course of status changes. Brackets signify optional steps.
5 Problems Associated with the Current Process

This section presents all the issues the interviewees have expressed in the interviews and quantitative information sources. As the interviewees are anonymous in this study, they are referred to as their role plus a number, e.g. CR1 is CR number one.

Many of the issues here are intertwined, but require different actions to improve. For example, most of the issues raised by the CRs involved unnecessary administrative procedures that they think are discouraging to do. As an extension of that, the amount of administrative procedures needed for simple cases is the same as what is needed for larger, more complicated, cases. Moreover the customers are often quite unaware of the CAR process which adds to their noncompliance with nonconformance reporting, resulting in longer lead times due to requests for more information.

There are two types of factors presented by people in different roles in the CAR process that increase the lead time for the cases resolved by the SQA function. One of the factors is the problems associated with waiting times when a CR cannot make any progress, e.g. when customers take long to ship the affected material, or when the NCR needs to be clarified. The other type factor is the discouraging factors of using the database and the established difference between fault and CAR, which means that the CRs as well as customers see problem resolving as separate from the CAR documentation instead of seeing the two as the same thing.

5.1 Input

This section presents the data from the interviews that point towards issues with the inputs to the process. Interviewees have mentioned that NCRs are of varying quality, either in terms of language when a translate software has been used or when the information in the NCR is insufficient, which poses a risk to extra time needed in order to start the issue investigation. The process depends on what the procedures are used at the customer site in terms of the quality of the NCR but also the level of active CAR management. This site dependence can be shown to play a significant part of the resolution time of an issue. Last in this section a part about how mistakes in the allocation of CARs, nonconformance cause change, affects the CRs work with problem resolving.

Nonconformance Reporting

Incomplete information in an NCR requires additional information from the the person who wrote the report in order for the CR to get to work on the CAR. Whenever the initial information contained in a CAR is ambiguous or unsatisfactory in any other way, the CR changes the status of the CAR to ‘Pending NC Info Update’ which automatically changes the process ownership back to the CO as
mentioned in Section 4.1. The Owner then contacts the supplier to request the specifics that are required for the CR to do their job. Since customers are involved to a varying degree in the CAR process, the level of detail in a nonconformance report can differ largely depending on who drafted it, for example a technician, assembler, manager, or engineer. However, CRs are reluctant to changing the status of the CAR when they require more information since that means that the case file disappears from their user interface view in the database which reduces their level of overview of their active cases (CR1; CR2).

An estimated figure of 20% of CARs have insufficient information and requires additional input from the customer (CR1). However, as can be seen in Figure 10, five percent of the active delayed cases are listed as ‘Pending NC Info Update’. Information such as this is therefore not likely to be accurate because of the tendency to not change the status in order to keep the case file on their own user interface view.

The Communication and Controls Engineering function uses checklists that the customer site personnel have to follow when filling out a nonconformance report. The same checklist is then used by COs who go over the report and ensure that all the required details are described according to the Engineering division’s requests as this, in turn, reduces the number of requests for additional information (CO1).

![Pie chart showing the percentage of CARs older than 28 days in the different available statuses when they are On-going.](image)

The large corporation of which ENGINEERING CORP is a subdivision has numerous Enterprise Resource Planning systems and other information sharing applications. To add to this, sites in France write their nonconformance reports and CARs in French and the Germans write them in German. This adds a risk when the writing is translated by either a software application, or a person with a lower level of technical knowledge which has a discouraging effect to thoroughly work with the CAR (CR2). However, CR1 does not see this as a large problem and cannot think of any instances where he has been hindered in his work because of it.
Site Dependence

Since the SQA unit is a functional organization, i.e. it is involved in many projects at the same time, it sees different processes and routines when it comes to nonconformance reporting as opposed to the project oriented functions which are mainly only involved in one project’s site and its process and routines. Attributing the process variation to be dependent on site, CR1 stated that some sites report issues well while some do not. For instance, some sites make sure to file a claim with the supplier as well as with ENGINEERING CORP and include all the proper documentation in order to ensure ease of keeping track of the two claims for the CR. This affects the lead-time positively as the supplier can start its work with the claim immediately, while if it does not receive anything from the customer, it will not start its investigation until made aware of it by ENGINEERING CORP.

Other than cutting down on lead-time, this approach also makes it easier for the CRs to follow up on the progress on the supplier’s end. At some sites, this process does not work very well, and the CR has no way of knowing if the supplier has received any claims from the customer in question. If they have received a claim, it is also difficult to know for certain which CAR that claim should be tied to.

The UK site has its own personnel responsible for creating the CARs in the system. The CO therefore often does not see the case file until it is ready to be presented to the customer, who in this case is the one that created the CAR file in the first place. Instances where the CO sees the CAR before it is ready to be presented to the customer is when there needs to have more information from the customer, a repair report if such has been conducted by the customer, or the actual piece of faulty equipment needs to be sent to ENGINEERING CORP for inspection and repair. Basically, the UK site is more directly involved in the CAR process and also actively monitors on-going CARs including, and most importantly for the figures presented in Figure 11, the closing of old and no longer important cases (CO1).

There is a rather noticeable difference in how quickly cases from different sites are resolved. Since the COs in the warranty claims department work towards their site only, and of three projects investigated there is a significant reduction in average resolution time as shown in Figure 11. The mean value for the UK site is about half of that of the German and French sites.

The three projects of comparable size are carried out at three different sites. As can be seen in Figure 11, the UK site sees faster resolution time than the French and German sites. This difference is explained by the fact that the UK site keep better track of their cases and in many cases they close open CARs that have been resolved, or are no longer of interest.
Figure 11  Boxplot of resolution times for three active projects. The UK site has a mean of 100 days while the French and German sites have means of 150 days.

Nonconformance Cause Change

The nonconformance cause is an information input field that decides which function (e.g. engineering, manufacturing, project management, supplier quality assurance) a new CAR gets sent to. A nonconformance cause change happens when a CAR is originally erroneously set as caused by one function, when a different function is the real cause. In the event of a CAR getting mislabeled as originating in a certain function by a CO or site administrator, that status could change when it is received by a CM. Erroneous cause labeling happens due to the fact that the administrators and COs have limited knowledge when it comes to certain complex issues that do not have a clear nonconformance cause.

When a CM receives a relabeled CAR they should notify the CO so that they can take the proper necessary actions associated with a cause change. In the case of relabeling a case as ‘supplier’ the Owner then sends out a request for a remark from the concerned supplier. However, this notification does not always occur which could cause the CR to wait for a remark for which there is no request. Alternatively, there might be a request for remark, but it is not tied to the CAR.
The proper workflow for when a CO correctly labels a case as caused by a supplier is that the supplier is notified of the nonconformance through a remark requested from them. This remark is then the basis for reference between ENGINEERING CORP and the supplier’s different analyses of the issue, see Figure 12.

As shown in Figure 13, the process is slightly longer when the nonconformance cause has to be changed, here shown in the example of the cause being set as ‘Manufacturing’. When the Manufacturing CM sees that a case that should not be investigated by their function, but instead by the SQA function, the manager changes the nonconformance cause to Supplier. When the SQA CM receives the case and sees that it has had its cause changed, the SQA manager should notify the CO of the change. This step is usually not carried out, and therefore the supplier is not made aware of the nonconformance until the designated CR inquires it. Because of this unawareness, the supplier has not been given any chance to do its own investigation yet and therefore lead time is increased.

5.2 Process

A major part of why CAR cases go seemingly unresolved is the fact that the SQA unit has limited resources and some of its other tasks take up a lot of time. However, the SQA interviewees all agree on that the intricacies of the process’s administrative side inhibit their inclination to complete the CAR documentation even if they contain and resolve an issue. Simply put, the system for CARs is not user friendly according to the interviewees.
User-friendliness of the Database

The database for CARs is used by the Resolvers only in conjunction with case resolution, and as a user interface, it offers little flexibility and choice. The way Resolvers track and find the cases awaiting their attention is by opening the CAR database, sorting by CR, then clicking on their name which then lists all of that person’s active CARs. As mentioned, when a case belongs to a CR, it has ‘On-going’ as status. Consequently, this means that when a CR changes the status to ‘Request more nonconformance information’ or ‘Request repair report’ the case disappears from their view, making overview quite difficult (CR1; CR2).

To cope with the lack of visual representation and overview, CR1 uses a spreadsheet with all the information from the cases in his view in the CAR database. He then sends this spreadsheet to different stakeholders where he has designated boxes for the concerned supplier where they fill in actions taken or observations made by them. This spreadsheet then allows the CR to keep track of status changes without cases exiting his view and in turn he reduces the level of administrative hindrance and the use of a database with limited functionality and for which he has limited knowledge.

Repeated Faults

Some nonconformance problems resurface every once in a while, or a new problem generates numerous CARs, contributing to a longer list of problems when in reality the problem is lone and the items affected is a plurality. This requires the CR to solve one problem, but manually close all of the open cases. An incident that CR1 brought up was rust in a certain type of pipe, an issue that has been known for three years and has been resolved countless times. However, these cases are treated and resolved individually using the same criteria as other, more severe, cases. This repetitive work is for obvious reasons not very stimulating for the CR, and therefore prefers to perform other duties instead once he knows that the appropriate compensation has been sent to the site that filed the nonconformance report upon which the CAR is based (CR2).

CARs are created for each faulty component. If a component that is delivered to many different sites turns out to have a systematic problem, and many different parties file a claim, there will be one CAR per each of those claims. Since the resolution is the same for all of these CARs it would make sense to be able to just apply the same resolution to all of the concerned cases, but instead the system requires individual treatment for each case, which further complicates the administrative work required by the resolvers.

Categorization and Prioritization

All cases that come to the Resolvers’ attention have some kind of importance to mainly the customer. It could range from a halt in their operations to a need
to replace a part that failed in accordance with an accepted failure rate curve (PQA2).

Today, there is no difference indicated in the CAR database as to whether a case affects the . CR1 expressed a need for categorization of issues. Basically, when a case ends up in his pile of CARs to resolve there is no way to know beforehand how severe the problem is, if it will require a lot of time, or if it is a frequently occurring issue. A specific idea that he would like to see implemented was the following, with three different levels of workload required in order to resolve the issue.

- One-time fault
- Investigation requires maximum eight man-hours
- Full-scale investigation

These levels then had different reporting requirements. The first level, one-time fault, requires only a report that states if any action was necessary such as sending new parts, reimbursement, *et cetera*. The second level is for slightly more serious issues that requires some more investigation with issue containment, root cause analysis, and an implementation plan for the recommended course of action. A full-scale investigation implies that the issue is large by comparison and needs a lot of attention in order to be contained, find the root cause, and setup a plan to decrease the probability of recurrence.

The fact that there is no way to categorize CARs contributes to the unwillingness by the SQA employees to work with them. One thing that CRs said was that frequent cases would come up as CARs needing to be resolved, when the impact of these issues is small and the normal solution to the problem would commonly be to file a warranty claim and request replacement material or repair. Since these are quite easy solutions the CRs have mentioned that they see it as a waste of their time to update the CAR in the system, as the problem has already been attempted to be resolved numerous times, but the supplier has yet to implement any measures that would eliminate the root cause.

**Inappropriate Culture**

Inappropriate culture can undermine the effectiveness of a process. Corporate culture is more powerful than directives and is ultimately what dictates employees’ behavior when it comes to anything outside of designed routines. The data suggests that the corporate culture at ENGINEERING CORP allows for job responsibilities not to be performed. One of the interviewees said that he does not work with CAR, even though it is part of his duties. This data suggests that the culture has some attributes which accepts this behavior. While it is possible that this fact is a product of priorities in a resource-scarce business function, the underlying issue of that it takes place at all suggests that it is allowed by culture rather than directive.

Customers do not see their issues resolved on time. This is another thing that rests on the culture environment where there is a lack of customer focus by the
individuals working with these issues. The process itself has a customer focus, but that focus is circumvented by the CRs as they choose not to comply with the process completely. Since the process has a customer focus, and the directive from management is to comply with the process, it can be attributed to culture as it takes place anyway.

The CAR process seems unimportant compared to the issue resolving. Combining the fact that the SQA CRs do not perform a set out duty with the disregard for a response time suggests that they see the CAR process as unimportant and therefore acceptable not to do. The CRs differentiate between resolving issues and performing the CAR documentation of the issue, as explained by the interviewees. This complacency can be attributed to the corporate culture and contributes to the feeling that customers do not require the information set out by the process design, and the process itself generates only extra work for the employees.

5.3 Output

As with most processes, CAR has its proponents and opponents. The people who are reluctant to using CAR have ended up being unaware of many of the process’s functions and properties. One example that Resolvers keep addressing is the burden of having to copy solutions to open CARs that have the same solution as something else; this is something the COs have said they will do for the Resolvers.

Interviewees have expressed a general notion of the organization and its people being quite ambitious, but the ambition to fully roll out all the solutions that are consistently being developed is lacking. In the CAR process, this is characterized by the fact that the process itself is developed without the presence of the Resolvers.

One of the main reasons for why the SQA employees do things that are not dictated by the CAR process is because they do not see it as value adding to the customer. Cases that are still unresolved in to the CAR database, but in reality have been solved, are a common occurrence. One CR said that he thinks his time is more valuably spent performing other tasks (CR2). Due to the fact that the SQA function has many other more directly value-creating activities to perform, the fact that the CAR process mainly concerns information forwarding makes Resolvers prefer to more tangible work tasks over formal reporting.

The interviewed CRs all agree that they have time issues which requires them to choose how to spend their time. “I cost a certain amount every hour, so I prefer to do what I think adds the most value to both my employer and suppliers” (CR2). This quote summarizes quite well how the CRs see the value of their work with CAR. There is a preference to solve problems and make sure that customers have products that perform according to requirements, whereas the CAR reporting process provides little value to the customer compared to the problem solving. When asked why CR2 does not fill out the CAR documents he responded that he gets more faults while spending time filling out CARs and that problems need his attention more than documentation.
Problem solving and CAR reporting are two separate things (CR2). Whenever he has resolved a fault, the formal report is an extra task that does not contribute to the problem resolution and is therefore of lesser importance to both himself and the customer (CR2). Since he is good at resolving problems, one of his core competences required for the job, drafting an additional report which also requires him to write in English is of low value.

The process customer is quite unclear to the CRs at SQA. Oftentimes when someone in the organization is dependent on a swift CAR resolution, they will communicate their need for one and are happy once the problem is resolved (CR1; CR2). This means that since they do not request any CAR documentation, there is no immediate customer for that part of the process. As CR2 put it: “When the project managers or PQA sees that a problem is resolved, they are most often happy. But the CAR is not filled out”. This notion carries with it the idea that the resolved problem is different from, and more valuable than, the CAR documentation.

5.4 Other Issues

The two main objectives of using a FRACAS process such as CAR are to improve the overall quality in all operations and to collect and analyze data to identify possible improvement areas (Hallquist and Schick, 2004; Lee et al., 2010; Villacourt, 1992). As an effect of the CRs’ difference in procedures compared to those in the process description, CAR collects information that is not accurate. In order to attain the goals of the FRACAS process, these concerns need addressing.

The non-use of the CAR database’s status change function, which the CRs prefer not to use in order to have cases stay on their own overview screen, inhibits the process improvement. Since the CAR process is a closed loop system and is reliant on accurate information to function properly (Hallquist and Schick, 2004) accuracy is a key objective for the information input to the database. In the case made by the CRs in this study, the non-use of status change functions in the database means that the correct status is not mirrored by the status listed in the database, and durations for a case’s circulation among the statuses are inaccurate.

Customer requirements is a driver for action, but as mentioned in the case of CAR the customers are not aware of the contribution to their business CAR has. Since customers are not involved in the process improvement, of which they are a major stakeholder, managers (both the SQA CM and higher-up quality managers) show little interest in the process and instead focus their team’s efforts in different areas where they see a larger interest to perform well. In turn, this gives the SQA CRs less of an incentive to perform their duties in the CAR process. This creates a circle in which a mutual lack of understanding acts as a common denominator, as depicted in Figure 14.
Figure 14  Circle of influence contributing to low leadership interest. The customers’ limited knowledge of CAR yields a low interest for the process from the CM which in turn gives the CRs a low incentive to fulfill the CAR objectives.

The implemented process does not have a satisfactory level of feedback between the different roles in Figure 14. The customer does not tell the CR or CM when it is satisfied with the investigation, and inversely the CR does not communicate to the customer when the NCR is good. As stated by CR1, the lack of feedback from customers contributes to low motivation in providing a thorough CAR analysis. In general, there is a lack of support and commitment from the leading people in the organization for the work that CRs are expected to put in.

The people producing for the process, the CRs, do not have enough training in how to use CAR. The process is design to be a tool for resolving issues, but the CRs see problem resolution and CAR is two different entities. This leads to the CRs not following procedures laid out in the process description in an attempt to better fit the process’s deliverables, such as the case of CR1 who has designed his own spreadsheet for communicating with suppliers and customers, or CR2 who says that he completely disregards the CARs but rather focuses on resolving the issues. These two answers suggests that people do not conform to process requirements.
6 Improving the Process

There are a number of ways to come to terms with the problems identified in this study. This section presents documented research solutions to these identified problem areas in the same process order as the previous two sections. The data in Section 5 has shown that it is clear that the Resolvers see the administrative work they have to do as a hurdle to resolve CARs. In order to make the process more lean, and thereby better align it with the company’s general strategy concerning lean manufacturing and lean thinking, the user-friendliness of the system needs to be investigated in terms of if it is waste or if it cannot be avoided in order to fulfill other strategic objectives. The frequent status changes, while useful for data tracking, unnecessarily transfer the ownership of active CARs away from the CRs which discourages the use of status changes which means that the true data of status changes is not recorded. Other than that, the implementation of checklists for faults labeled as NC Cause ‘Supplier’ can increase the level of quality in the NCRs. However, the underlying issue here can be interpreted as the intangibility of an internal service’s value contributes to a lack of a feeling of usefulness when performing the service.

6.1 Input

Standardization

Standardization is a powerful instrument to keep quality conformance and should also be used for process input. In this case, since the process is dependant on external input, a thorough checklist with items that cover all of the necessary information that would be used by both the person writing the NCR as well as the CO when writing up the CAR. Checklists is already used by one of the engineering functions in the organization for this very purpose, and expanding it to include the SQA components would, according to the lean principles, be a step towards a more lean process in terms of standardization (Swank, 2003).

Segregating Complexity

Similar to standing in a queue at the bank where the person in front of you seems to have to resolve a million things, a good process needs to have its assignments categorized and prioritized. This serves two objectives, first it becomes easier for an individual to plan their schedule when they know approximately how long it will take to resolve a case, and second the level of urgency is indicated by the priority. These conditions should be set by the CO at the time of CAR creation. Since some faults are recurring ones and therefore have lots of information on how to approach them in the database, they require less effort to resolve according to the CRs and segregating CARs by frequency is therefore meaningful. Secondly, each submitted NCR affects the production at a customer’s site in some way, meaning that the
impact of an issue can either be causing a halt in production, or not affect it at all. As a result of that, the dimension of impact serves a purpose on the CAR. To illustrate the two dimensions, a matrix was created, see Figure 15. In the interest of both resolving CARs as well as to ensure that an existing problem in any of the four quadrants in Figure 15 does not move to an adjacent, less attractive, quadrant, a number of different approaches could be executed to match the urgency of the problem pertaining to its quadrant.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Unique severe problem</td>
<td>Systematic issue</td>
</tr>
<tr>
<td>Single occurrence</td>
<td>Repeated minor issues</td>
</tr>
<tr>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 15**  A model for categorizing CARs given two conditions: frequency of the type of fault to occur and the impact the faulty equipment has on the customer’s operations.

Single occurrences refer to accidents that end up contributing to nonconformance, such as forgotten torque markings, random error in paint job, loose tape or similar. Basically, to be considered a single occurrence an event has to be caused by a temporary malfunction in the work flow. Since these events are uncommon and unforeseeable, it is difficult to work proactively to reduce their occurrence. In addition to that, the fact that the impact is low reduces the sense of urgency to take the time to examine a CAR which exerts Single Occurrence characteristics.

An untreated Single Occurrence CAR could risk becoming a Repeated Minor Issue. A move towards this quadrant is for obvious reasons an unwelcome event and will incur higher nonconformance costs.

A repeated minor issue could be two things: something that is expected to have a certain degree of nonconformance, but nonetheless generates a CAR thanks to, for instance, supplier noncompliance with existing quality control requests. It could also be a systematic problem that has not been given the appropriate attention, as
A unique, severe, problem is something that there is no existing knowledge of how to solve and that requires immediate investigation. This type of issue requires a cross-functional task force that tirelessly works to resolve the costly issue.

A systematic issue is different from the unique, severe, problem in the way that there is knowledge of how to solve the issue thanks to the fact that the type of issue has occurred before.

6.2 Process

Poor process implementation is one that all the interviewees mentioned items within, and some of the other issues previously presented in this section could belong under this heading as well. These issues are looked upon and analyzed in terms of their contribution to process implementation here. For one, on a basic level, the results suggest that a process designed to return a resolved case within 28 days but fails to do so is due to a poorly implemented process. Going beyond that, other items of poor process implementation are the complicated database interface, poor training, no classification or prioritization, repeated issues that already have a solution, different sites having different procedures, and NC cause change procedure.

The complex and non-user friendly administrative system is evidently the largest obstacle for the CRs to fill out the database forms. The mentioned hindrances are the difficulties associated with keeping a good overview for oneself. This limits the amount of personal responsibility and ownership associated with a CAR. The database is designed so that ownership is only maintained for parts of the time the CAR is active. The findings from this study suggest that this contributes to low motivation when it concerns carrying out the change of status from the CR’s ‘On-going’ to, for example, the CO’s ‘Pending material’ signifying shipping the faulty equipment to a repair site. This status change, which removes the CAR from the CR’s user interface in the database, contributes to the lack of feeling of ownership and thereby the feeling that the process itself is a nuisance. The effect of going in and out of ownership in a CAR creates a disconnect between the CR, the issue, and the CAR.

The CAR process does not facilitate a sufficient level of training for those involved in the process. There are discrepancies between what the procedures are and what the SQA CRs know, which suggests that the training and communication of procedure updates do not work as intended. This was exemplified by the findings where the CRs on the one hand were saying that the repeated cases require them to close them all individually, when in actuality the laid out procedures say that the CRs should resolve one of the repeated CARs and send the the resolution along with the CAR reference numbers that have the same resolution to the responsible CO for administration. Similarly, the issue of nonconformance cause changes, where the COs stated that active cases that have been changed from one nonconformance cause to ‘Supplier’, suggests the training and communication are lacking as well as
well. Good training is a necessity for a lean process (Womack and Jones, 1994) and each process owner needs to treat their function as a school with a learning focus.

Empowerment of Employees

Empowerment can mean different things to different processes. In this study, two opportunities to increase the empowerment has been revealed: the use of reviews, and the constant ownership transfer between CAR statuses. Lean service means that review activities should be avoided, and the activity in the CAR process that should be done away with is the CM’s approval of the CR’s investigation. This is also suggested by the fact that was presented in Section 4.3 that investigations very rarely get unapproved. This loop-back works as an extra step in the process without adding any value to the process, while reducing the level of personal responsibility for the investigation since the CRs do not have an appropriate level of accountability due to the fact that the investigation must be approved by a manager. The new process compared to the one presented in Figure 9 on page 39 is presented here without the approval activity in Figure 16.

Figure 16 This new simplified process flowchart takes into account the empowerment of the CRs and does not have the approval activity. Compare Figure 9 on page 39.

As described in Section 4 there are lots of status changes in the CAR process where ownership and responsibility of a case file is transferred back and forth. This is experienced as a demotivating issue by the CRs as described in Section 5. The tedious and counter-productive status changes contribute to a loss of the sense of responsibility, as well as having a harder time to have an overview of the case files each CR is investigating. While the status of a CAR is helpful for data analysis, it provides nothing other than a loss of ownership for the CRs when it is they who are the ones performing the investigation. This issue should be solved by always letting the CRs’ user interface view in the database display their active cases, including the ones that are awaiting further documentation or equipment, while at the same time being displayed on the CO’s view when it is relevant for them.

Balancing Workloads

A part of the lean thinking in any type of process is to balance the workload so that one person has a large amount of work to do, and others have little to do. In this case, as some components are more likely to cause problems at certain
time than others, a common pool of cases where anyone with the knowledge of the affected component can resolve the case will alleviate some of the uneven workload. Especially useful for low impact cases, this approach also uses the fact that many of the CRs have knowledge of components that are not their own, but may have been in the past. This would create a possibility for more work sharing where appropriate.

**Process Knowledge**

Since process knowledge is linked to process performance (Slack and Lewis, 2011) it is useful to assess what the knowledge of a process’s activities and procedures truly are. In the case of CAR there are obvious differences between what the procedures are and what people do. The CAR process shows signs of being on the fourth stage of Bohn’s (1994) process knowledge scale. That means that the process is well measured and controlled but needs to stabilize the interface and conditions between process activities and process products. An example of the low level of process knowledge is given by the fact that the CRs are unaware of the process of having the COs handle CARs that have already been solved or are under investigation.

One of the main process knowledge issues is the fact that the CRs see CAR as different from problem resolution when the intention is that they are meant to be the same thing, CAR should be the tool to use for resolving problems. The feeling of disparity between the problem resolution and CAR is a contributor to the low level of use of the process, and needs to be countered in order to fit the purpose of the process.

Improvements that go unknown by the process’s practitioners are no improvements. Increasing the process knowledge for the CRs is important to achieve any improvements to the process. Ideally, an improvement program of CI workshops where all the SQA CRs can increase the process knowledge (Johnston, 2008) and knowledge of other people’s roles in the process, as well as function as a forum for improvement suggestions. Going back to the process knowledge scale, the data suggests that the mean value of the CAR resolution time can be controlled but the CRs do not have the knowledge of exactly how their work affects the development of the process. Essentially, the process knowledge should be shared to a larger extent with the CRs to reduce the gap in process knowledge between the COs and other managers in the organization working with developing and reviewing the process.

**6.3 Output**

**Customer Focus**

The customer focus is misaligned with the customers’ own wishes. Even though the process itself has a customer focus in terms of giving them accurate and concise
information regarding their claims and their resolution process, they are mostly interested in having their immediate issues addressed. This suggests that the process has a too large focus on the effectiveness and customer, and is lacking in the efficiency focus so to the extent that the process is not performing according to its current requirements. While the purpose of CAR is to constantly improve quality in delivered components, this long-term value point bypasses the customer’s requirements as of now, since otherwise the customer would put pressure on more timely and accurate CAR documentation. The process itself tries to tell the customer what it wants, rather than focusing on a collaborative initiative where the objectives are aligned between the organization and the customer to fully understand the value in the process. In other words, the process is too focused on effectiveness compared to efficiency and needs to improve the latter to achieve a sustainable process, as illustrated by Figure 17.

Figure 17  *The improvement cycle illustrating the shifting focus to achieve sustainable processes.*

Another aspect suggested by the findings is that despite the fact that the process is very dependent on what customers write in their NCRs, insufficient resources is spent on improvement. One business function uses checklists to ensure that NCRs concerning its responsibilities contains all the necessary information for them to start the investigation without delay. The use of checklists could serve as an initial form of increased customer engagement in the process, boding the way for a higher degree of customer involvement in a process that they are supposed to benefit from in terms of ever-improving quality products.

6.4 Summary of Improvements

The problems that accompany unresolved CAR cases are for the most part of communicative nature. In order for the process procedures to be known and followed by the SQA CRs, better communication of the procedures is therefore recommended. However, communication is often mentioned as an improvement area, and is therefore left at that. This section focuses on the other improvement areas, which are more concrete.
Since time management is very important for a resource-strained function like SQA, segregating complexity through classification and prioritization is important. This would create the ability for CRs to not waste any time assessing if they have enough time to work on a certain case.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Improvement suggestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low NCR quality</td>
<td><strong>Standardization</strong> of NCRs according to checklists</td>
</tr>
<tr>
<td>Knowing which CAR to solve, and when</td>
<td><strong>Segregate complexity</strong> so that it is known if a problem is unique and/or important to solve quickly</td>
</tr>
<tr>
<td>Unnecessary approvals</td>
<td><strong>Empowerment of employees</strong> to match the level of personal responsibility for the SQA employees and to bridge the commitment to the customer with the commitment to the process, as well as improving the database to always show their active cases</td>
</tr>
<tr>
<td>Uneven distribution of CARs</td>
<td><strong>Balancing workloads</strong> and encourage more work sharing by, for instance, having a common pool of CARs that anyone can work on</td>
</tr>
<tr>
<td>Employees do not follow process guidelines</td>
<td><strong>Inappropriate culture</strong>. Make sure that employees follow the process descriptions so as to not circumvent the objectives of the process</td>
</tr>
<tr>
<td>CRs know less than necessary about the process</td>
<td><strong>Process knowledge</strong>. Include the employees directly in the development of the process</td>
</tr>
<tr>
<td>Insufficient process focus</td>
<td>The <strong>customer focus</strong> has taken too much room so that the process has become inefficient as a result</td>
</tr>
</tbody>
</table>

**Table 10  Summary of improvement suggestions.**

Reaching higher process knowledge can also benefit from being applied outside the organization. As can be seen here in Table 10, Low NCR quality does lies outside the organization to some degree, and is therefore a different challenge compared to the internal issues. However, through increased process knowledge both inside and outside the organization, more supplier interest could be achieved which then provides a better chance to have suppliers engage more in the activity as they learn how they benefit from it.
7 Discussion

This study has investigated the causes of poor process performance in a FRACAS process in a global engineering corporation using principles from lean service, to provide an initial foundation for lean FRACAS. The FRACAS process uses information about faults to implement corrective actions and to increase quality performance in a continuous cycle. This was done by studying the design and people’s perceptions of the CAR process in a large engineering corporation, an example of FRACAS. This thesis accomplishes two things: first it suggests that FRACAS can be classified as an internal service process and secondly, based on that, provides an initial foundation for lean FRACAS in terms of how it could be designed and characteristics of the involved activities. While there is research on what lean internal service is, FRACAS is a specific case and there are no cookie-cutter approaches to make any internal service lean (Maleyeff, 2006) since such services can be entirely context driven (Suárez-Barraza et al., 2012) and therefore very different from one another. This Discussion presents how the study has contributed to knowledge in terms of how it differs from previous research on FRACAS, and what the findings mean for the concept of lean FRACAS. It also mentions criticism to the concept of lean service, and suggests further research and the limitations in the study.

Since the concept of FRACAS is theoretical and few companies successfully reap all the benefits of it (Hallquist and Schick, 2004), most research on the topic is focused on how to implement a process based on this concept (Lee et al., 2010). The results from this study show how FRACAS has been implemented in one organization, and that the difficulties found are in line with previous research. This study differs from the other works on FRACAS in terms of using lean as an improvement tool, which, as mentioned before, enables a foundation for the concept of lean FRACAS.

The findings show that there are a number of factors that affect the process performance negatively. The main item of concern is the notion of disparity between fault and CAR, which was expressed by the CRs. This suggests that the long lead times can be explained to some extent by the fact that CAR is seen as secondary to the investigation as opposed to seeing the investigation being a part of CAR. This idea of separation is solidified in a number of ways, such as CRs not following procedure regarding CAR status and ownership changes and the database’s lack of user-friendliness. In other words, these findings suggest that this FRACAS process, in its current state, is not compatible with the contingencies in the SQA function. Either because the process does not well accommodate those contingencies, or because the knowledge level is lower than necessary in order to see the value in the process. As such, the case presented ample opportunity to use lean service process improvement aimed at this internal service. In accordance with Maleyeff’s (2006) internal service structures, the FRACAS process in this study displays the common structures for internal services, such as information as the main deliverable, cross-functionality, and hidden costs and benefits. This proves that FRACAS is an internal service by these measures. The difference in the case of CAR is the connection with external parties, and therefore a thorough value stream assessment is harder to achieve. In light of that, the improvements suggested in this study are
based on internal activities only, which restricts the effectiveness of the improvements. However, the investigated situation shows much room for local improvement to the activities that take place internally. These improvements are the basis for lean service, and are in line with existing practice (Swank, 2003). In addition, the FRACAS process in this case exhibits a clear case for how the customer focus can overreach the wishes of the customer and that focus diminishes the focus on the process’s efficiency (Radnor and Johnston, 2012) by the fact the customers only want their problems resolved and not excessive documentation. The customers’ position on the FRACAS process and documentation is known by the CRs and therefore they justify not performing the process as customer orientation.

There is little personal responsibility in terms of the FRACAS process, which makes increasing employee empowerment a major concern for lean FRACAS. The constant stream of ownership transfer connected to the status changes in the process further establishes the perception of CAR being separate from problem resolving activities. The implication of this is that when the problem is resolved and the customer is happy, the CAR process poses as an extra work activity that offers no tangible value to a customer, as opposed to taking on a new case and resolving that. Basically, on the one hand the CRs are in contact with suppliers and customers to resolve a problem, and on the other hand the case is taken away from them if they need more information. Moreover, the obtrusive non-user-friendly database presents itself as a tedious extra step of writing up a report that is more conclusive than what is deemed necessary for the some cases. Basically, the process requires the CRs to follow procedures that reduce their level of personal responsibility, which lowers the employee empowerment. For example, simple cases where the root cause is self-evident and an implementation plan is straightforward can make the CAR documentation demotivating to fill out. In addition, the low process knowledge can be attributed to the empowerment (Suárez-Barraza et al., 2012), since low responsibility sparks a low interest in participating in the process’s development. In fact, the results suggest that the perception of intangibility of an internal service’s value (Maleyeff, 2006) contributes to a lack of a feeling of usefulness when carrying out the service.

The issues in the CAR process of organizational complexity, lack of prioritized goals, and ineffective and inefficient data tracking are consistent with research on FRACAS (Hallquist and Schick, 2004). Organizational complexity grows as the process itself expands to involve more people and information does not get communicated effectively to all the stakeholders of the process. This was shown by the fact that CRs were unaware of some of the procedures in the process, such as how to deal with repeated cases. The lack of prioritized goals were evident due to the CRs’ opinion of problem resolving being one thing and CAR another. The SQA function prioritizes keeping their external customers and suppliers happy, while the internal customers could not fully rely on the database that serves the purpose of tracking CARs. Lastly, ineffective and inefficient data tracking was a strongly worded and frequently mentioned concern, and not changing the status of the CAR means that inaccurate data is recorded. Furthermore the CAR process gets its data from different sources depending on site specific procedures for who records the failure data,
contributing to a non-ideal FRACAS process.

While there are opponents to the concept of lean service, the fact that there is no one definition of should also be considered. Seddon et al. (2011) argue that the purpose of services are meant to absorb the variability that production creates, and lean sets out to remove the variability in services which in turn risks making both processes too rigid and prone to large disturbances. But, considering the degree to which lean service has been used here, perhaps the true value of lean service exists not in viewing service as production. Instead the value lies in doing more, better, which ultimately is the vision for any organization. In this context, lean service means to use the resources available in a suitable manner and give the resources the tools they require.

7.1 Limitations and Further Research

This study comes with two main limitations. First, the internal-only perspective limits the whole overview of the process from how customers view and use their reporting to enhance their gains based on their reports and cooperation. The same is true for suppliers. Consequently, any changes made to the process involves the customers to some degree and the impact of that has not been addressed in this study. Furthermore, the contextual contingencies on which these results are based makes it difficult to say that they are valid in general, however that is to be expected from internal services. In order to set up general guidelines for lean FRACAS more case studies are needed to find crossover points to make generalizations for the concept.

Second, the results in this study are based on a very small number of people, in a small functional unit of a large corporation. In order to validate the results further, a larger investigation is needed.

Additional studies to be carried out the continue this study is to set about an implementation of the changes proposed in this study, and measure their effectiveness to further contribute to the area of lean FRACAS. Another area to research is the resource variable in terms of lean internal service. This study does not consider resources as something that can be changed, however solely focusing on the impact of lean internal service or FRACAS on time or people requirements could shed more light on the usefulness of lean service.
8 Conclusion

This thesis has investigated the performance problems in an application of FRACAS in a large engineering corporation and shown how lean service and internal service process theory can be used to identify areas for improvement in a FRACAS process. Striving to fill a gap in lean FRACAS as a concept, the study has drawn on existing research on internal service and the FRACAS concept as a whole to find areas for improvement according to lean service.

Through interviews with the employees at the case company on four different levels of responsibility – administrators (CO), a manager (CM), specialists (CR), as well as a business strategist (BD) – it was found that there were a number of different factors that lead the employees to avoid using the FRACAS database in the extent it was designed for. Basically, the system created a number of barriers to usability as employees found it difficult to track their own cases in a satisfactory manner. On top of that, there was no indication of what cases were more important than others, which caused the employees to treat pressing issues the same as non-critical cases. There is compelling evidence that the studied process with a target of resolving issues within 28 days is not well suited for a function that have external parties on both ends. However, looking at the process as it is shows that the employees were separating between FRACAS and problem resolving, the former being a process they are not responsible to the customer in and the latter where they are. While sufficient knowledge of a process is required for totally empowered employees, the findings here suggest that combining FRACAS with lean lessons such as empowerment of employees, segregation of complexity, balance of workloads, and standardized input would pave the way towards lean FRACAS.
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Škrinjar et al.


