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Process Performance Improvement through a Successful KPI System

Guidelines to build a successful KPI System to improve the performance of the fault management process of a Network Provider Company

Metropolia University of Applied Sciences

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Foreword

I want to express my deepest gratitude to all Industrial Management Master’s program professors, and specially Timo Hietala and Sonja Holappa for their guidance during this thesis project. Also, I want to thank all my colleagues and coworkers that collaborated with me and made carrying out this project possible.

When I left university after completing my Communications Engineering Bachelor and received my first salary, I told myself I would never return to university. I had finally escaped the academic world! But I could not have been more wrong, and I am incredibly thankful for that. Participating in the Industrial Management Master’s program and fulfilling this Master’s thesis while working full-time has been challenging. Balancing deadlines, projects and Saturday morning lectures was not easy, but now that I look back, I can appreciate the impact that this Master’s program, and this thesis in particular is having on my career. Academically expanding my knowledge in industrial management, has enabled a new perspective and relationship I have with my daily work, being able to always understand the bigger picture, and increased the speed with which I am navigating my professional career. This thesis project will always be a reminder to myself to never give up learning and to continuously challenge and expand my horizons.

Abstract

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This Master's thesis aims to improve the performance of the fault management process of a Network Provider multinational company. This process is critical for the development of mobile network products that bring more than 10 bn EUR in revenue to the case company year after year. The fault management process is not operating efficiently, and some symptoms of this are high fault leakage to customer networks, slow fault correction time and unproductive synergies between different teams participating in the process.

This report explains the current state analysis of the fault management process, where it is argued that the root cause of the process underperformance is its KPI system. It also researches and elaborates on relevant literature findings and best practices applicable to solve the observed flaws. Then proceeds with the co-creation of a solution and set of guidelines on how to build a successful KPI system around the fault management process and finally, the validation stage of this proposal.

This thesis followed an applied research methodology, consisting of multiple interviews and workshops conducted with employees from the case company, alongside in-depth corporate documentation, and relevant literature. Following this approach, the achieved outcome of this thesis is a set of guidelines on how to build a new and successful KPI system that aligns the fault management process with the case company strategy and recovers its optimal performance.

Keywords: Fault Management, Business Process Development, Key Performance Indicators, KPI System, Process Performance Improvement.

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List of Abbreviations

CEO: Chief Executive Officer
CF: Conceptual Framework
CMO: Chief Measurement Officer
CNN: Correction Not Needed
CSA: Current State Analysis
CSF: Critical Success Factor
CuDo: Customer Documentation
FAO: Fault Analysis Owner
FCB: Fault Control Board
FCO: Fault Correction Owner
FM: Fault Management
FOT: Feature Owner Team
FRA: Fault Report Author
FVO: Fault Verification Owner
HW: Hardware
KPI: Key Performance Indicator
KRI: Key Result Indicator
MN: Mobile Networks
PI: Performance Indicators
QM: Quality Manager
R&D: Research and Development
RACI: Responsible, Accountable, Consulted, and Informed
RAN: Radio Access Networks
RI: Result Indicator
SW: Software

1 Introduction

The fault management process is a crucial aspect of modern software businesses, playing a relevant role in ensuring the reliability, stability, and overall performance of software applications. Software systems are constantly evolving, and encountering faults or errors is part of the modern development lifecycle. The fault management process is designed to identify, analyse, and address these issues, minimizing disruptions in production and enhancing the user experience. Effective fault management not only safeguards the reputation of a software business but also contributes to customer satisfaction and retention.

Fault management has a direct impact in the development cadence and customer satisfaction of a company, thus it must be ensured that a company invests enough resources in this process, and that it is optimally defined. A malfunctioning fault management process will slow down the development velocity of a company, causing delays in critical deliveries that usually entail financial penalties, and will also degrade customer satisfaction, most probably causing a decrease in market share.

In this thesis, the current state of the fault management process of a network provider company is analysed, and through thorough applied research, a series of improvement suggestions for this process are assembled.

1.1 Business Context

The case company of this Master’s thesis is a network provider. The role of network providers is to define and produce the needed hardware and software that network operators will purchase to offer network capabilities at national level to the end user. Nowadays, the case company is one of the biggest b2b network providers in the world, and it divides its activity into four business groups:

1. Mobile Networks
2. Network Infrastructure
3. Cloud Network Solutions
4. Technology Patents

The addressed business challenge is located in the Mobile Networks Business Group, which participates in an industry with fierce competition and low profit margins where only big technological companies can survive.

At the moment, the flagship product in the industry is 5G, a cutting-edge technological product that combines both software and hardware. Like any software product, 5G is constantly evolving and improving via software upgrades and new developed features, driven by the tight race between the different network providers, each trying to get their product ahead of their competitors.
The case company participates in this technological race with a development approach that combines both Trunk SW development and feature based development methodologies, where thousands of developers are constantly integrating software changes to dozens of software components that combined form its 5G product. This is an extremely complex activity, and to sustain this high-paced development and ensure maximum product quality, the case company has a considerably big Verification structure inside R&D, formed by a diverse set of testing teams, that find and report product faults, and developer teams that fix those faults. During 2023, more than 40000 faults were reported, approximately 90% of them were reported by internal R&D Verification and 10% by customers. For obvious reasons, the case company intends to minimize the number of faults reported at customer level, to achieve higher product quality and in consequence improve customer satisfaction, and to do so, Verification acts as a filter, that should minimize the number of faults that reach customers, ideally none.

This Verification organization is mainly driven by the fault management process. This process describes the lifecycle of a fault since its detection in a testing environment until its closure, when the fault has been resolved. The fault management process is the object of this Master Thesis because it is not operating effectively at the moment. Figure 1 shows Mobile Network business group process organization, where the fault management process is mapped:

Figure 1: Mobile Networks Business Group Process Organization

As shown in Figure 1, the fault management process falls into Continuous Integration, Testing and Delivery group, which is directly interacting with Continuous SW Development and Platform & HW Development, but as mentioned, this thesis focuses on SW faults due to time limitations.

1.2 Business Challenge, Objective and Outcome

The fault management process driving the Verification activities is not operating optimally. This can be observed in the high ratio of customer reported faults to internal reported faults, which is an indicator of low product quality and cause for poor customer satisfaction. Additionally, unproductive synergies between testing and development teams have been observed, potentially caused by the current list of monitored Key Performance Indicators which are not well aligned with case company’s strategy. These issues also cause slow development cadence and inefficient usage of resources.

Improving the fault management process is necessary to improve product quality, thus improving customer satisfaction and ultimately increasing 5G market share.

Accordingly, the objective of this thesis is to create suggestions that improve the performance of the fault management process. Section 2 describes the research plan defined to reach the objective and produce a set of suggestions that improve the performance of the fault management process.

1.3 Scope and Outline of the Study

The 5G product is a combination of complex software and hardware, and the verification structure of the Mobile Networks business group intends to identify faults in both these dimensions. The fault management of software or hardware flaws shares similarities, but this thesis focuses on software faults, as the development and implementation of software corrections is an activity of more relevance for the case company and is operated differently to hardware-related faults.

The fault management process treats faults reported both internally and at customer level. The focus of this thesis is on how to improve the internal fault management process, and therefore there should be less faults that reach customer level.

This thesis work is structured with four main pillars, all crucial to define the needed set of improvements for the fault management process. Firstly, the conducted current state analysis of the fault management process is explained, where the main flaws of this process are identified by consulting corporate documentation, a series of interviews with key stakeholders and a workshop with participants of the process. Following the current state analysis there is literature work, where the best practices regarding business process development, and specially fault management are consulted. The thesis continues by assembling a series of improvement suggestions to the identified weaknesses of the process, and finally these suggestions are reviewed by key stakeholders of the company.

The previously described body of work is structured in 7 sections. This is the first section, serving as introduction to the business challenge at scope, its context, and the stated objective of the thesis. Section 2, project plan, shares in detail the procedure and stages defined to reach the thesis objective and outcome. This is followed by the main body of work of the thesis, consisting of the current state analysis of the process in section 3, the literature and best practices research in section 4, the co-creation of a solution for the case company business challenge in section 5, the validation and improvement of the initial solution in section 6 and as closure of the thesis, discussion and conclusions in section 7.

2 Project Plan

The following section describes the selected approach and methodology to conduct this Master’s thesis, alongside a series of strategic decisions, and respective justifications, made to ensure an effective and successful outcome.

2.1 Research Approach

The plan and research approach chosen to conduct a thesis project is of high importance. The selected approach needs to be aligned with the nature of the project to ensure that the outcome of the thesis is of relevance to its intended objective.

Kananen (2013: 26-45) describes multiple research approaches that rely both in qualitative and quantitative research. The three main classifications used by Kananen are case research, action research and design research. This thesis is not limited to studying a phenomenon, as its objective is to create a solution to a real business problem, so case research methodology was discarded. Action and design research methodologies are very similar, with a key difference relying on the role of the author of that research. The author of this thesis participates in the object under analysis, the fault management process, and this facilitated the investigation work, but the author does not have the responsibility or influence to directly change the functioning of the fault management process or its operations, so action research methodology is not suited for this thesis.

Design research, also known as applied action research, is the methodology that best serves the purpose of this Master’s thesis. Drawing on Kananen (2013: 29), the main reasons why design research was selected are that abductive reasoning is followed, the purpose of this project is to suggest a change in the case company and that the author is acting as an external participant.

Kananen (2013: 59-91) elaborates on the main stages of a design research project. The main stages are defining a problem, researching and analysing the causes of this problem, presenting a solution, testing and adjusting during potentially multiple iterations and drawing conclusions from the design research. The main body of the thesis has been visibly influenced by Kananen's defined steps for design research and is explained in the following sub-section.

2.2 Research Design

The body of work of this thesis is divided into four main sequential stages to achieve the aimed outcome, a set of suggestions that improve the performance of the fault management process. Figure 2 depicts the research design of this thesis consisting of four stages aligned with design research approach.

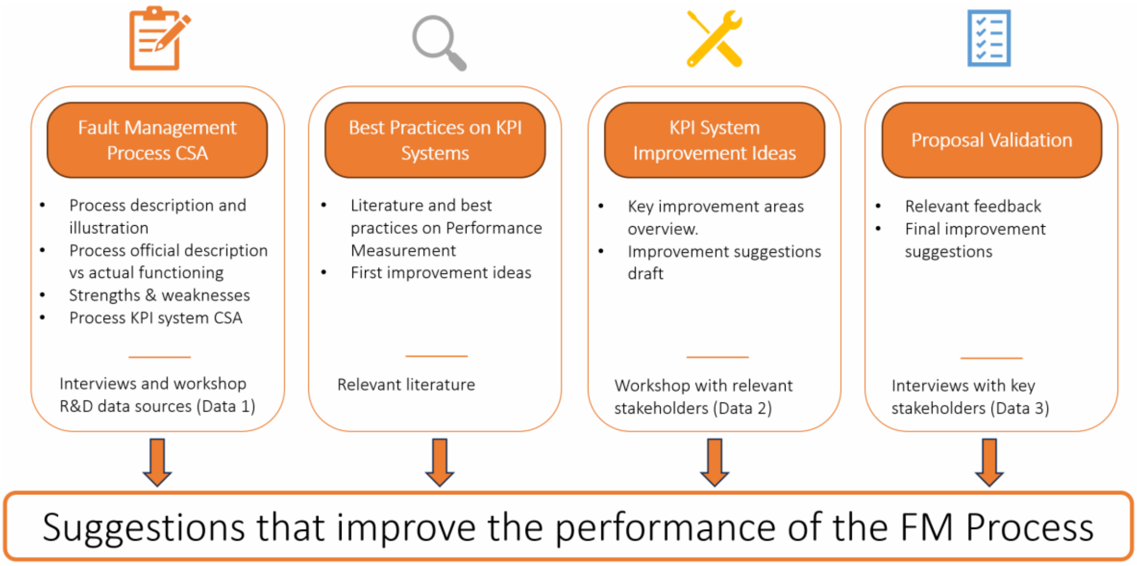

Figure 2: Thesis Research Design

As shown in Figure 2, the research started with the current state analysis of the fault management process. This research was conducted through consulting official company documentation, R&D performance data, a series of interviews to relevant process stakeholders and a workshop with process participants. This research allowed in depth understanding of the process functioning and the identification of its weaknesses.

The current state analysis was followed by relevant literature research about best practices on process performance management and recovery, mostly focused on the Key Performance Indicator concept. This work allowed to start conceiving potential improvement ideas to the main weaknesses of the process.

The problem diagnostics resulting from the current state analysis stage together with best practices and contributions found in relevant literature were used as input for a workshop that included process relevant stakeholders, where the initial set of suggestions were co-created. In the last stage of the thesis research, the set of initial suggestions was validated and fine-tuned with the feedback from three key stakeholders, with the aim to increase the chances of success of the solution proposal when presented to the case company leadership. More detail on the created contents and respective inputs of each stage throughout the thesis project is explained in the following sub-section.

2.3 Data Plan

Stages one, three and four, explained in the research design, produced the main three data contents of this thesis, eventually concluding in the set of improvement suggestions. In Figure 3, the outcomes of each stage can be seen, and how those were obtained in more detail.

Data	Content	Source	Informant	Timing	Outcome
Data 1 Fault Management Process and KPI System CSA	• Process Description • Process Illustration • Process Relevance • Strengths and weaknesses • KPI System CSA	• Corporate documentation • R&D Performance Data • Interviews • Workshop • Survey	• Architects • Test Engineers • SW Developers • Quality manager • Fault Coordinator • Verification Project Manager	January-February	• Process detailed overview • Process Strengths and weaknesses • KPI system CSA
Data 2 Suggestions for Process Performance Recovery through KPI System	• Process performance improvement guidelines	• Workshop	• Architects • Test Engineers • SW Developers • Quality manager • Fault Coordinator • Verification Project Manager	March	• Initial draft of process performance improvement guidelines
Data 3 Proposal Validation	• Validated set of suggestion and feedback	• Stakeholder interviews 1 to 1	• Senior Quality Manager • Transformation Manager • Strategic Program Manager	April	• Final version of suggestions for a successful KPI System

Figure 3: Data Plan

Figure 3 shows the three main data blocks produced by the thesis work, their content, the sources of information and the consulted stakeholders, the timing of those activities and at last, the outcome of each stage.

This thesis mainly follows qualitative research methods in order to gain an in-depth understanding of the case company business problem, without intention of generalising. These methods are interviews with relevant stakeholders, workshops with process participants and corporate documentation. Additionally, in order to triangulate the data sources that enabled the root cause analysis during the CSA stage, a quantitative method was used. This consisted of processing and quantifying the results of an internal survey of the case company.

All the observations and decisions taken during the thesis project are based on evidence and logical reasoning, following abductive reasoning to find the most plausible assumptions and conclusions in the limited given time.

Next section dives into the current state analysis of the fault management process to familiarize with the business challenge, understand why it is nor performing optimally, and identify its main weaknesses that need to be addressed.

3 Current State Analysis of the Fault Management Process

This section contains the current state analysis of the fault management process and the followed methodology to conduct it, alongside with the conclusions made from the main process stakeholder's feedback. The feedback was used to list the strengths and weaknesses of the process, and to narrow down what areas of improvement are of most importance.

This section covers the applied research methods followed to synthesize the process CSA, consisting of multiple interviews and a workshop with relevant stakeholders of the fault management process, an open survey to the process participants, and deep research through company official documentation. With all the collected data, the process is illustrated and described with a special focus on the fault management execution workflow.

3.1 Overview of the Current State Analysis

Mobile Networks, and precisely 5G, is currently the most important product of the case company when it comes to revenue, and its operations are of significant complexity due to the variety of international customers that the case company serves with diverse needs. Consequently, tens of thousands of employees are allocated to this product, and the vast majority of these contribute in multiple ways to the fault management process, which supports the whole portfolio of products of the Mobile Networks business group. The significant dimensions of this process posed a challenge for the goal of this master's thesis, but in order to overcome it, and be able to produce an accurate current state analysis, an exercise of narrowing down the scope was done.

The dimensions that were narrowed down so that the scope of the business problem was feasible are product and employee roles. The fault management process supports the lifecycle of different mobile networks products, such as 2G, 3G, 4G and 5G, also Internet of Things related products and private networks. The instances of the fault management process for all the listed products are similar, but for simplicity's sake, only the 5G product was chosen. As has been explained before, 5G has a software-hardware duality, and faults in both are managed through the fault management process, but this thesis has focused only on software faults to narrow down the scope of the problem and maximize the chances of relevant improvement guidelines.

The fault management process is of vast complexity, and many different roles contribute to it on a daily basis. During the initial research through corporate documentation of the current state analysis 71 different roles were identified as process participants. Such a large pool of contributor roles could not be covered by this thesis, and therefore through a filtering exercise, the relevant list of roles was reduced to 16. This exercise discarded customer support roles, hardware-related engineers, low relevance roles, redundancies and Pronto tool related employees. Changing the pool of contributors consulted during the initial applied research had an impact on the feedback used to build the CSA, so this exercise was done carefully to have an addressable, relevant, and representative group of interviewed roles. The resulting list of chosen stakeholder roles is the following:

Architecture & Specification Roles:

- System Architect

Verification Roles:

- SW Engineer
- Test Engineer
- Technical Leader
- Test Architect
- Local Product Owner and Area Product Owner
- Verification Project Manager

Project / Program Office Roles:

- Program Manager
- Fault Manager
- Process Owner
- Fault Co-Ordinator

Operations, Transformation and Quality Roles:

- Operations Manager
- Quality Manager

FOT (Feature Owner Team) Roles:

- FOT Leader

Performance Management roles:

- Performance Management Lead
- KPI Owner

As explained in the following section, the fault management process consists of multiple subprocesses, that allow for multiple fault management executions to take place in parallel. The object of this thesis is the workflow of a single fault management execution, thus minor level of attention was spent on the support subprocesses of the fault management, such as management, maintenance, preparation, support, capability, change management and feature screening.

For the CSA research, four individual interviews were conducted with a quality manager, fault manager, system architect, and a test engineer. These interviews were structured with a series of open questions, and root cause analysis with multiple "why" follow-up questions as described by the 5 Why's methodology. Additionally, a workshop including the following roles was organized: 2 Test engineers, fault manager, architect, quality manager, fault coordinator, technical leader and SW engineers. The content of the interviews and workshop was used to describe and illustrate the fault management process, and additionally evaluate key strengths and most critical weaknesses that are listed in the following sections.

3.2 Process Description and Illustration

The current fault management process is of high complexity because of its scalable nature. In order to ensure that hundreds, or even thousands, of product faults are being investigated and corrected simultaneously, the fault management process is supported by many subprocesses that can be seen in Figure 4. The time framework of the fault management is of the same cadence as the case company Mobile Networks releases. Each year is divided into a certain number of releases between 2 and 4. Each release contains a certain amount of newly developed features and products that will be offered to customers. In order to ensure the correct development of all of these software features, each release has its own instance of the fault management process, led by a selected group of program managers and coordinators that take care of these long lead subprocesses, which then grant that the development of each release coexists with the handling of hundreds of faults in parallel.

First the complete process overview is described at a release level, and later special attention is given to a single fault management execution workflow. Figure 4 shows the release overview of the fault management process:

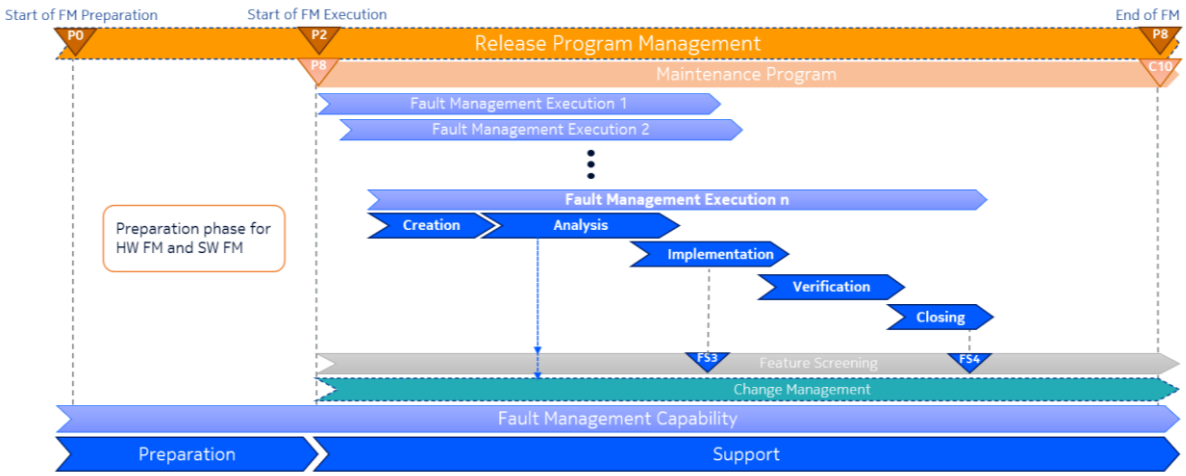

Figure 4: Fault Management Process Overview

Starting from the top of Figure 4, the Release Program Management subprocess can be seen. This subprocess is in charge of ensuring a successful release development from a general perspective. It is to be noted that the release is bounded by P0 and P8 milestones. P0 determines the start of a release, P8 its closure, with a total of 9 respective milestones.

Once a release has reached P8, its development phase has ended, it is released to customer and it enters the maintenance phase, where the case company ensures its correct functioning at customer level. The maintenance phase is bounded between P8 and C10 milestones, but it is not of major relevance to this thesis, as the focus is on internally reported faults during the development phase, instead of customer reported faults.

The bottom part of Figure 4 depicts the fault management capability, preparation, and support. In general, these subprocesses concentrate on the needed efforts before the start, and during the release, to ensure that there are enough resources to handle the constant inflow of reported faults, and that the company resources allocated to verification and software correction are well employed.

The focus of this thesis are the fault management executions, which can be seen in parallel during the duration of a release. Each fault management execution represents the lifecycle of a reported fault. Hundreds of them are happening in parallel during a release, even reaching numbers above a thousand at the same time, which causes a big stress on the verification and development capabilities of the case company. In order to avoid this overflow of faults addressed in parallel, the fault management has a mechanism to incentivise the rapid handling of faults, or to only report faults with a high degree of confidence, through KPI motivation, but as it is explained in the weaknesses section, these mechanisms might not be operating correctly. It can be observed that the fault management executions are divided into 5 steps: creation, investigation, implementation, verification, and closure. These are studied in detail later in this study.

From the fault management executions, two paths can be observed towards additional subprocesses called feature screening and change management. These subprocesses handle some technical decisions triggered based on fault investigation, for example the case where the requirements of a feature might change due to unrealistic expectations set before the feature was integrated in the final product, or a needed change in the customer documentation to inform the customer that a certain product configuration should not be used. But neither of these subprocesses are part of this thesis scope.

Next, special focus is placed on the fault management execution workflow, its official definition and the current workflow followed.

3.2.1 Fault management execution workflow

As already stated, tens of thousands of employees with up to 71 different roles interact with the fault management process on a daily basis, however, only a reduced representation of these roles englobes the vast majority of the process participants that participate in the fault management executions. Consequently, the accumulated successes, or failures, of each of the fault management executions, are the main factor of a successful fault management process throughout a release.

When consulting official company documentation, the fault management execution workflow looks scarcely detailed. Figure 5 shows the officially documented fault management execution workflow:

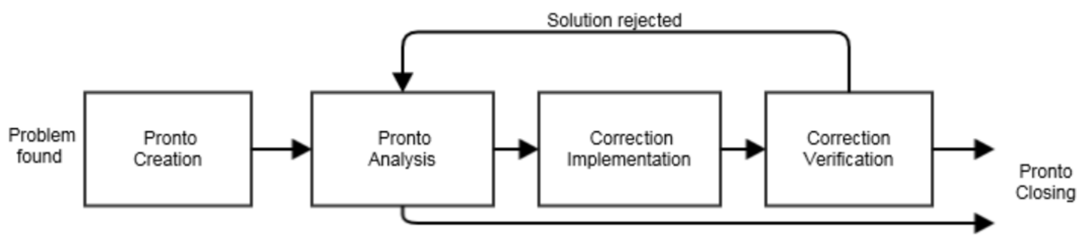

Figure 5: Official Fault Management Execution Workflow

Figure 5 shows the 4 main phases of the fault management execution workflow, consisting of Pronto creation, Pronto analysis, correction implementation and correction verification. Pronto is the given name to a fault report in the case company, and it also gives the name to the digital tool that supports the fault management execution workflow. From now on, reported faults will be referred to as Prontos. A Pronto is created by a test engineer when a potential product fault is found. The report attached to a Pronto has a standard template, where the test engineer details a significant amount of relevant information that is later used by fault coordinators, fault managers and developers to investigate the fault, select the team responsible for that fault and implement a correction.

The actual workflow of a fault management execution is more complex than the official documentation explains. Figure 6 shows the complete workflow of a fault management execution based on the fault management process stakeholder interviews and review of the Pronto tool:

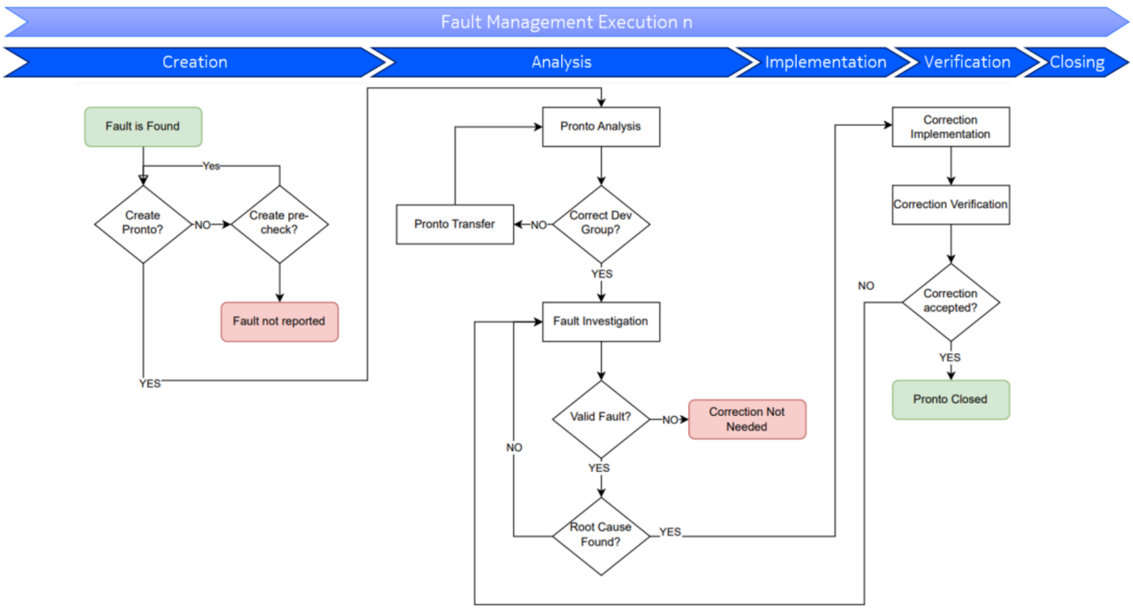

Figure 6: Fault Management Execution Workflow

In Figure 6 the detailed fault management execution workflow is illustrated. 5 steps englobe the complete lifecycle of a Pronto: creation, analysis, implementation, verification and closing.

The creation stage starts when a test engineer finds a potential fault through product testing activities. The test engineer can then raise a Pronto to start the official fault investigation if he or she has reason to believe that the product is not meeting the needed requirements. If the test engineer is not completely sure about the genuineness of the observed fault, he or she can opt for the pre-check procedure. This procedure consists of unofficially contacting relevant developers or fault coordinators for them to pre-investigate the observations of the test engineer and assess if an official Pronto should be created or not. The pre-check procedure was created to protect test engineers KPIs, in particular the rate of discarded faults, meaning the reported Prontos that actually did not report a true product fault. With or without feedback from the pre-check procedure, the test engineer can decide to create a Pronto and forward it to the suspected developer group responsible for that fault.

As previously stated, a Pronto consists of a fault report with extensively relevant information. This information is analysed by the developer group first assigned by the test engineer. The developer group will accept the Pronto and proceed with the fault investigation if the fault is under their responsibility. Otherwise, another developer group will be selected, and the Pronto will be transferred to them, hopefully in a friendly manner through the hand-shake procedure. This will be repeated until a developer group accepts the ownership of the fault, and continues with its investigation to evaluate if the fault is valid, and in such case look for a correction. If the fault would not be valid, for example because of wrong expectations from the test engineer, or a flaw in the conducted test, the Pronto will be closed with Correction Not Needed result (CNN). The CNN tag will damage the test engineer KPIs because it is understood that resources were wasted on a non-existent fault.

In case the Pronto is reporting a valid fault, developers will drive the investigation until the root cause is found, with support from the original test engineer, who can conduct additional tests under request by the developers. Such requests would be triggered by the need for additional troubleshooting logs needed of a test, or testing of multiple hypothesis that can guide the developers to find the root cause of the fault in the software.

Once the root cause is found, a correction is implemented, generally in a fraction of the time that the analysis required, but still the implemented correction will require verification from the test engineer. Thus, he or she ensures that the fault has been corrected, and no other problem has appeared because of the software change. If the verification of the correction is positive, then the Pronto will be closed. Pronto closing will also entail a series of actions, such as correction communication or improvement actions to avoid such faults in the future. These last three stages of the Pronto lifecycle have a tight time constraint, as they are seen as the stages where the resolution of a Pronto can speed up to improve the process KPIs.

The main stages of the fault management execution workflow are described in further detail below.

3.2.2 Fault management execution stages

This section lists the inputs, outputs, and key activities of the 5 main stages of the fault management execution. Some key process roles are listed that are explained in the following section.

Creation:

Inputs	Key Activities	Outputs

• Internal reported defects detected by development and integration & verification
• Security vulnerability report by Security vulnerability monitor
• Affected products/items
• Information about negative consequences/severities, if correction is not available
	• Create fault report
	  • Internal fault report
	  • Vulnerability report
	• Collect symptoms
	• Assign fault report to initial suspected/affected unit
		• Fault report assigned to a SW or HW unit or documentation for routing to correct responsible organization
		• All collected symptoms and data
		• Completed new fault report in FM-tool (Pronto)
		  • Internal fault report
		  • Vulnerability report
		• Fault Analysis Owner named

Figure 7: Inputs, Key Activities and Outputs of the Creation Phase

Analysis:

Inputs	Key Activities	Outputs

• Fault report assigned to a SW or HW unit or documentation for routing to correct responsible organization
• Fault Analysis Owner named
• All collected symptoms and data
• Completed new fault report in FM-tool
  • Internal fault report
  • Customer fault report
  • Vulnerability report
	• Fault Analysis Owner coordinates correction analysis activities for all impacted parties
	• Technical analysis:
	  • Update definition of affected units
	  • Detailed analysis of fault impacts on all existing and future releases
	  • Description of the technical reason of the fault
	• Summarize analysis results
	• Propose implementation plan for all affected units/releases
	• Initiate Process Root Cause Analysis and Escape Defect Analysis
		• Documented analysis results collected and consolidated
		• Affected SW build documentation
		• Identified baselines, versions of SW that need to be corrected
		M: Implementation plan proposed
		  • Proposed build plan
		  • Proposed Test plan
		  • Proposed schedule for correction implementation, releasing and delivery
		• Process Root Cause Analysis and Escaped Defect Analysis

Figure 8: Inputs, Key Activities and Outputs of the Analysis Phase

Implementation:

Inputs	Key Activities	Outputs
• Decision to start fault correction implementation • Decision about versions of SW Document to be corrected Necessary budget and resources allocated and planned • Updated and approved Implementation plan • Analysis results	• Review and update implementation and test plans • Design and implement the requested correction • SW Module Test • Summarize implementation results and start verification	• Implemented SW Document • Corrected Customer Documentation if affected

Figure 9: Inputs, Key Activities and Outputs of the Implementation Phase

Verification:

Inputs	Key Activities	Outputs
• Implemented SW Document • Produced SW builds • Corrected Customer Documentation • Implementation note • Test plan	• Define test scope and verification planning • Verify the implementation according to implementation and verification plans • Summarize and store verification results	• Verified SW build • Verified Customer Documentation if affected • Collected results of verification phase

Figure 10: Inputs, Key Activities and Outputs of the Verification Phase

Closing:

Inputs	Key Activities	Output
• Verified SW build • Verified Customer Documentation • Collected results of verification phase	• Final closing of Fault Analysis. • Prepare and execute the delivery of the accepted Release Note to the needed parties • Communicate the results to the affected parties • Closure of the fault report	• Approved and completed release note • Fault Analysis result • Communication to all affected parties • Final closing of the fault report

Figure 11: Inputs, Key Activities and Outputs of the Closing Phase

For further understanding of the fault management execution, its roles are listed and explained next.

3.2.3 Fault management execution roles

As per official definition, the fault management execution has 6 key responsible roles. These are not to be confused with employee roles. These roles, and their areas of responsibilities can be seen in Figure 12:

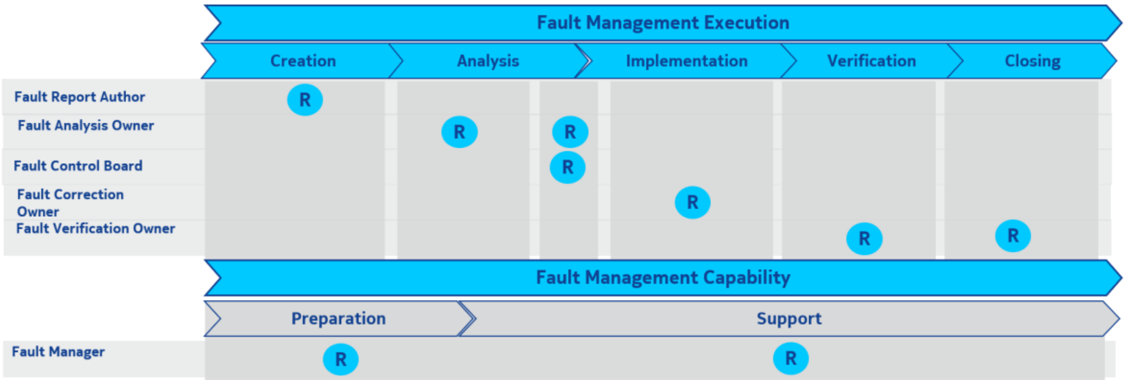

Figure 12: Roles and Responsibilities of the Fault Management Execution

In the above figure, six key roles and their responsibilities across the fault management execution workflow are listed. The Fault Report Author is the employee that creates the Pronto, thus reports the fault. The Fault Report Author is typically a test engineer, but SW engineers, architects or technical leaders often also report faults. The Fault Analysis Owner is the person in charge of the analysis of a Pronto from the selected developer group. The Fault Control Board keeps track of the overall Pronto situation and defines correction targets. This role is usually covered by manager roles. The Fault Correction Owner is responsible for the implementation of the fault correction in the software. Last, the Fault Verification Owner verifies the implemented correction and closes the fault report. Usually, the Fault Verification Owner is the same person as the Fault Report Author.

Having defined the fault management process overview, the fault management execution workflow, its stages and roles, the next sections evaluate the process strengths and weaknesses, with special focus on the process flaws.

3.3 Fault Management Process Strengths

The objective of this Master’s thesis is to create suggestions that improve the performance of the fault management process, so special attention is placed on the process weaknesses that need to be addressed, but it is also important to identify and understand the process strengths so that the improvement ideas of this thesis are aligned with the process strengths and enhance those.

From the discussions and feedback from the consulted stakeholders, three main strengths were identified from the fault management process of the case company. The process is fully digitalised, scalable, and supported by a tailor-made tool.

The fault management process is fully digitalised, enabling complex process performance analysis. This allows to evaluate the performance of the process with a data driven approach and enables the collaboration between international colleagues.

The process is fully scalable, as it can cover the fault management of the growing Mobile Networks portfolio, regardless of the number of customers and faults identified. This is due the critical and strategic work executed in the general subprocesses of preparation and support, external from individual fault management execution instances.

The third strength, which actually enables the two previously mentioned ones is the Pronto tool. The Pronto tool is an internally developed tool supported by SAP that digitally manages all faults that go through the fault management process: internal and customer faults, software, or hardware and from all Mobile Networks products, from 2G to upcoming 6G. This tool has been designed in accordance with the fault management process workflow, making sure that every step is followed and there are no oversights in execution.

Next, the focus is on the process weaknesses, identifying the critical ones and justifying the improvement areas chosen for this Master's thesis.

3.4 Fault Management Process Weaknesses

The pursued outcome of this master thesis is a set of improvement suggestions for fault management process of the case company. In order to produce relevant and concise improvement actions, the current state analysis of the process has been done with a highly critical approach, encouraging the interviewed process stakeholders to share the flaws and improvement areas of this process. When any weakness was listed during interviews or the workshop, a "why" question loop would be triggered to pursue the root cause of each weakness. The listed weaknesses are significantly diverse, as could be expected from such a complex process, where multiple stakeholders interact from many different perspectives and fields. The list of weaknesses includes the following: the fault management process followed KPIs are not productive nor harmonized, the Pronto tool is too complex, software troubleshooting features are limited, poor communication between departments, the pre-check sub-process is not followed, and the fault prioritization is defective. Each weakness is explained next.

The fault management process followed KPIs are not productive or harmonized is an assertive statement. Complaints or negative observations about how KPI's negatively affect the performance, confidence, or general employee well-being of the fault management process, were frequent. The case company, as most modern businesses, is a process driven organization, and as such, it strongly relies on KPI monitoring to evaluate its functioning and conduct continuous improvement of its activities. It was then surprising how a strongly negative perception of the followed KPIs of the fault management process was shared by all the interviewed stakeholders.

The test engineers complained about the Pronto tool. As previously explained, the Pronto tool is the SAP based internal tool used to report product faults and monitor its full lifecycle. This tool has been listed as one of the process strengths because it ensures that the process workflow is unequivocally followed, but still the key users of this tool such as test engineers shared their thoughts on how much time they waste interacting with this tool and complained on how it starts to be obsolete as the Pronto tool struggles to interact with new digital tools.

The software developers complained about the limited troubleshooting capabilities of the case company's 5G products, stating that the current self-diagnosis features are not powerful enough and consequently complicate the work of fault analysis and investigation.

Another widely spread flaw of the fault management process is the poor communication between departments and teams interacting through it. Poor or non-existent communication between teams often causes delays or misunderstandings that eventually slow the rate of fault correction and cause inefficient resource allocation. Examples of this would be poor communication between the testing and development teams, slowing down the investigation of a fault, or the isolation between testing teams leading to the same fault being reported in multiple places and then using unnecessary resources to target it.

The fault manager stated certain wrong doings with the pre-check subprocess. This practice consists of an unofficial approach from the test engineer to a subject matter expert such as a software developer to ask for advice on a potential product fault. This practice was recommended to test engineers to avoid reporting a fault that would eventually be discarded as correction not needed (CNN) and damage their KPIs. It has been observed that some faults are stuck in this pre-check mode for far too long because the test engineer is reluctant to start the official fault management process which could degrade its KPIs, or on the other hand, some faults stay far too long in the pre-check mode because subject matter experts do not prioritize this unofficial practice and their feedback is heavily delayed. It can be argued that this process flaw could be related to the first stated weakness regarding process followed KPIs.

The last process weakness in the list is its fault prioritization, described as arbitrary and defective. Each fault is given a priority level when reported. This priority level should be decided by the product performance impact, from unnoticeable to fatal, and if this fault could be in already deployed software in customer networks. On the contrary, the priority level might seem to depend on the phase of the release when the fault is reported, giving high priority by default to Prontos reported close to the release end and that might jeopardize its closure. A not uncommon situation results in a significantly high rate of faults having the highest level of priority, thus making it impossible to properly allocate resources accordingly to technical needs.

The listed weaknesses are multiple and diverse, thus too wide for the scope of this Master's thesis. As the field of the Master's thesis is industrial management, the weaknesses about the Pronto tool and limited troubleshooting features were not considered as potential improvement areas addressed in this thesis. To choose a main weakness to focus on based on a data driven and logical decision, the results of the case company Heartbeat survey were used. The Heartbeat survey is an annual internal survey where all company employees are asked about multiple business topics to make a snapshot of employee satisfaction and improvement areas for the company. One section of this survey is free text format question that allows employees to point out potential flaws in the company, and access to these answers was given during the research of this thesis. 80 answers were related to the fault management process, despite that this free text question is not specific to any process or business area. These complaints about the fault management process were then classified into 6 categories to allow a concise and quantitative assessment: KPI, management, execution, troubleshooting, Pronto tool and instructions. These reflect the main areas of complaint in the Heartbeat survey about the fault management process. Figure 13 shows the results of this survey.

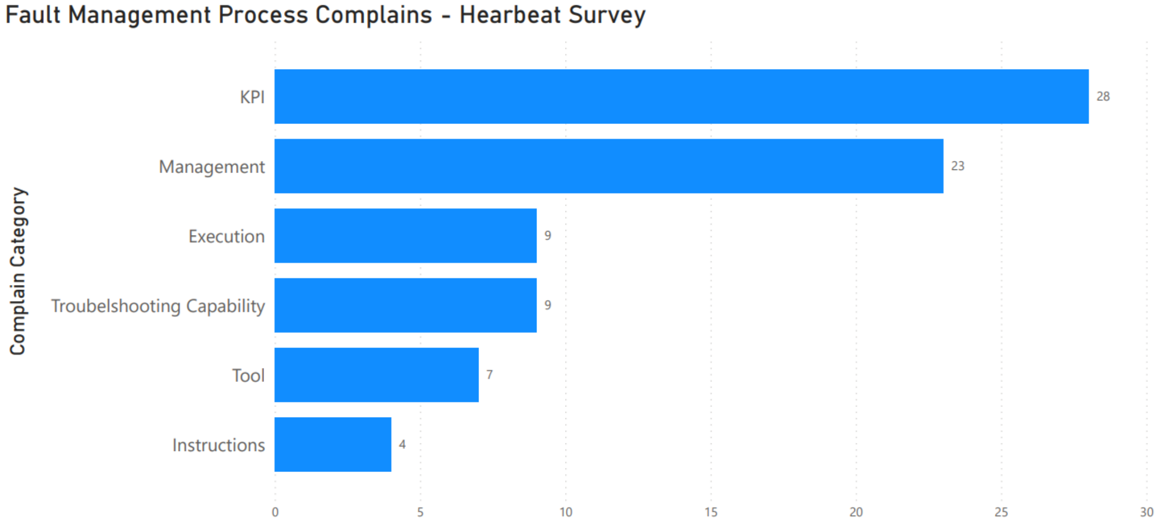

Figure 13: Fault Management Complaints in the Heartbeat Survey

In Figure 13, the processed data from the Heartbeat survey clearly shows that KPI related comments are the most common complaints about the fault management process. Mistrust in the process management is a close second, but these two can easily be related, as is justified in upcoming sections. The information from this survey and the feedback from process relevant stakeholders point towards the followed KPIs of the fault management process as the root cause of the process malfunction, thus it is the weakness that this thesis focused on. Next, further attention is given to the KPIs weakness through the current sate analysis of the KPI system that supports the fault management process.

3.4.1 Unproductive KPI's of the fault management process

Through the current state analysis of the fault management process, it is argued that the key flaw of the process is caused by the monitored KPIs of the fault management execution. These KPIs affect the decision making of process participants in unproductive ways. For example, a test engineer might be scared of reporting a potential fault because it could end in correction not needed (CNN) and damaging their personal KPIs. But how many faults are not being reported, and ending up in customer networks, because of fear of negative KPIs from test engineers? On the other hand, the currently monitored KPIs could be justifying why developer groups are highly reluctant to own the investigation of faults, and point fingers to other developer groups without proper technical justification, to reduce the number of faults that their team gets, only caring for a major KPI that monitors the time that a fault needs to be corrected. These are just certain examples on how poor KPI definition can damage the performance of an well-designed process.

Throughout the interviews and workshop, process participants where asked what they would change from the fault management execution workflow, or the overall fault management process. The received answers were rarely adding or removing steps of the process, or changing how something is done, rather improve the collaboration, improve the communication or the way things are done, and reduce the situations where confrontation arises. The conclusion of the current state analysis is that the fault management process is well defined, efficient, and lean, but only on paper. The process is not functioning properly, because the currently monitored KPIs create conflict whenever a process participant needs to make a decision during the workflow. Figure 14 shows the fault management execution workflow with the highlighted conflictive decision points.

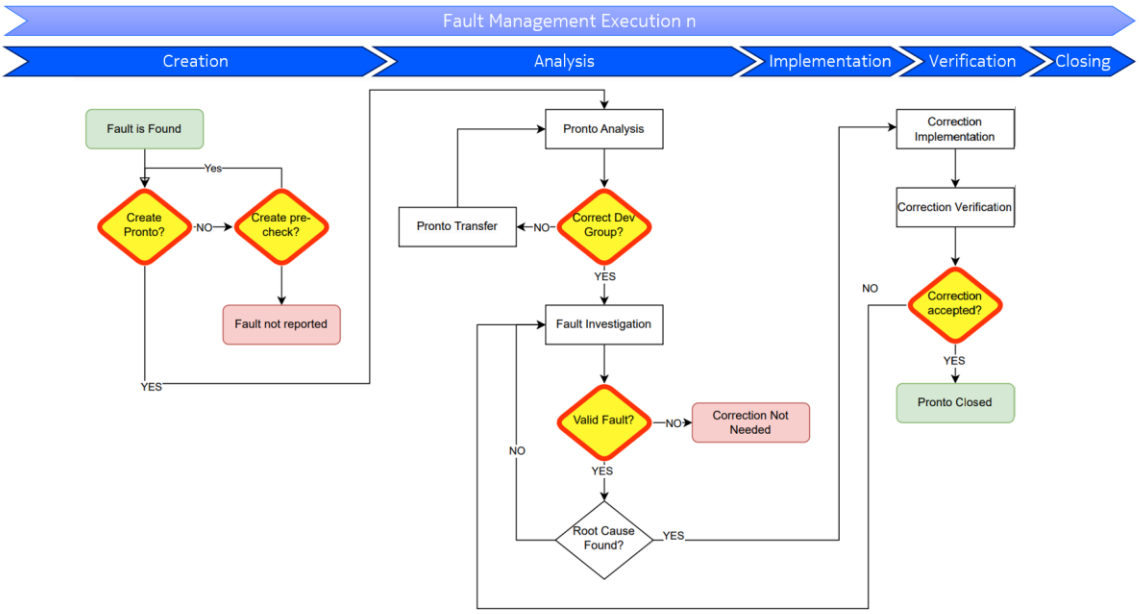

Figure 14: Fault Management Execution Conflictive Decision Points

In Figure 14 the 5 main decision points are highlighted. In all of these, it was identified that the process participants decisions could be negatively impacted by the currently monitored KPIs. In Figure 15 there are some examples that were mentioned during the applied research. For these scenarios, the roles described in Figure 12 will be used: Fault Report Author (FRA), Fault Analysis Owner (FAO), Fault Control Board (FCB), Fault Correction Owner (FCO), Fault Verification Owner (FVO) and Fault Manager (FM).

Role	Unintended scenario caused by negative influence of KPI’s.
FRA	Reports a fault that has already been reported by another group to boost their KPIs.
FRA	Does not report a fault because of fear of damaging their KPIs due to Correction Not Needed result
FRA	Abuses the pre-check procedure to skip official process workflow and not affect their KPIs.

FRA	Reports faults without proper technical evidence to boost their KPIs.
FAO	Sends a Pronto targeted for their group to another group without proper technical justification to boost their KPIs.
FAO	Discards a Pronto reporting a relevant fault to protect their KPIs
FRA and FAO	Do not properly collaborate because they see themselves as competitors or enemies.
FCB	Decides to attach Prontos without proper technical analysis to improve fault correction time KPIs. Attaching Prontos means that two or more Prontos are reporting the same fault by different teams, and will are treated as one after attachment.
FCB	Discards a Pronto attachment to not damage the KPIs of one of the fault management executions at the expense of the second.
FCO	Loosely sends multiple software corrections to the FVO trying to speed up fault correction time KPIs and thus inefficiently using company resources.
FCO	Does not pre-test their corrections and then jeopardize the health of the test lines and test equipment trying to speed up fault correction time KPIs.
FVO	Approves a fault correction without thorough verification due to pressure from FCB or FAO
FM	Overemphasizes the importance of the Prontos under their responsibility to receive more resources and improve their KPIs.

Figure 15: Unintended Scenarios Caused by Negative Influence of KPI’s

The list of negative scenarios of Figure 15, and many more, cause a malfunctioning of the fault management process, inefficient resource usage and product defect escaping to customer networks. Any action needed to reduce these and improve collaboration in the fault management process will need to be properly coordinated across teams. And the list of monitored KPIs should as well be the result of coordinated planning, but surprisingly it is not. In depth analysis of the current KPI system of the fault management process is explained next.

3.5 KPI System Current State Analysis

As the KPI system was identified as the main root cause for the underperformance of the fault management process, applied research was conducted to identify its main weaknesses to later suggest related improvement actions to improve the KPI system and consequently, the performance of the fault management process. This research method mainly relied on two interviews with a quality manager and a fault coordinator, and corporate documentation investigation.

A key finding during the current state analysis was that each department in the case company defines its own KPIs considering a loose set of guidelines that come from the company leadership. This means that each department that participates in the fault management process defines their own list of KPIs related to the fault management process. This situation is leading to departments prioritizing KPIs while considering their department alone, and not aligning with the company’s strategy. Moreover, KPIs from different departments can even be inversely proportional, creating negative synergies between teams. And to make this situation even worse, each year the list of KPIs is redefined at department level, although the fault management process has rarely been updated. This can cause that year after year, each department shifts their list of KPIs to KPIs that are more specific to itself, so that each department is in control of their results, which would be a good thing, unless this directly causes further misalignment with the company's strategy and the performance degradation of the fault management process.

The KPI system monitors an excessive number of KPI's related to the fault management process, exactly 1110. As is explained in the next section, a company should try to reduce the amount of monitored KPI's as much as possible, because KPI's focus the attention of the organization, and too many KPI's can distract employees from a correct workload prioritization.

Analysing the list of tracked KPI's it is easy to spot examples of KPI's that should not be considered as key indicators because of their low relevance, or even some indicators that are not measuring performance, rather operational results.

Most process stakeholders stated that the main critical success factor of the fault management process is quality, although the reply was not based on a statement from the company leadership. Despite this, most of the monitored KPI's are not really aligned with it. Many measure how fast are things getting done, and also some are related to inefficient usage of resources, but not many KPI's linked with quality are found.

It was easy to find clear examples of KPI's from different teams that could create counterproductive scenarios. For example, developer teams sometimes might state in the Pronto tool that a correction is ready for testing, when the software for it is not yet available. This would improve the correction time KPI of the developer team and degrade the KPI that measures correction verification time of the testing team. This is a scenario where teams are having minor conflict because of the KPI system, and the real time needed by the case company to solve that fault is not improving.

A very interesting weakness found about the KPI system is the strong influence that customer stakeholder has when defining KPI's of the internal R&D KPI system, even that those might be measuring internal faults that are found during product development, before this reaches customer. The case company's customers are network operators. When a fault is found in a live mobile network, the customer will report it back to the case company for it to be solved as soon as possible. Operators cannot afford to have critical faults in live networks, and that is the reason why all contracts between network providers like the case company and network operators present clauses that determine millionaire penalties for the provider depending on how long a critical fault is visible in the live network. With this background, the case company might have built a KPI system for fault management that measures and hence prioritizes how fast faults are resolved, instead of prioritizing solution quality or resource usage optimization. The problem comes when this influence by the customer stakeholder affects the whole KPI system, even if only less than 10% of the reported faults during 2023 were customer faults.

One more weakness related to the KPI system is its dashboards and visualization. A KPI system is as good as it is comprehensive. If the KPI's are represented in poor quality charts, or in obsolete dashboards, no decisions can be made out of those, and then these serve no purpose. Next, examples of an obsolete dashboard, and a chart with poor data visualization can be seen.

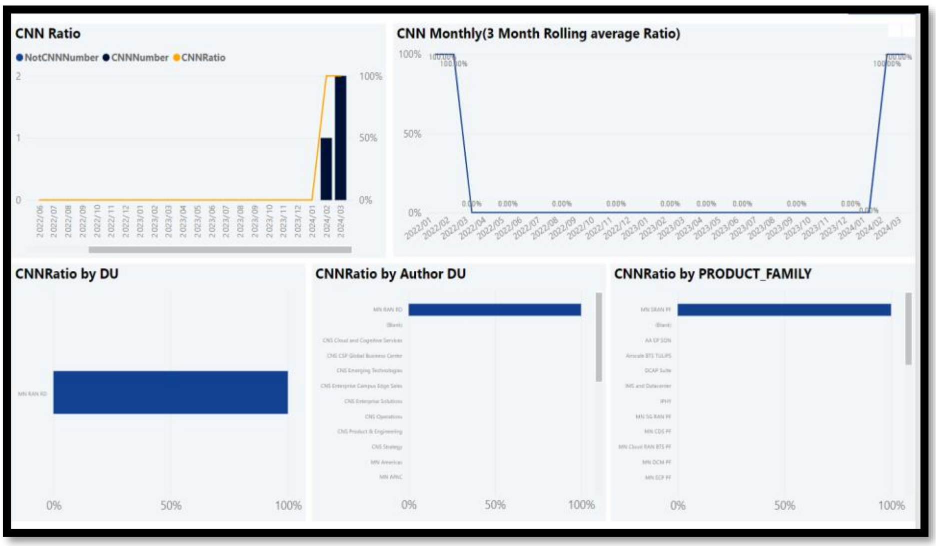

Figure 16: Obsolete KPI Dashboard

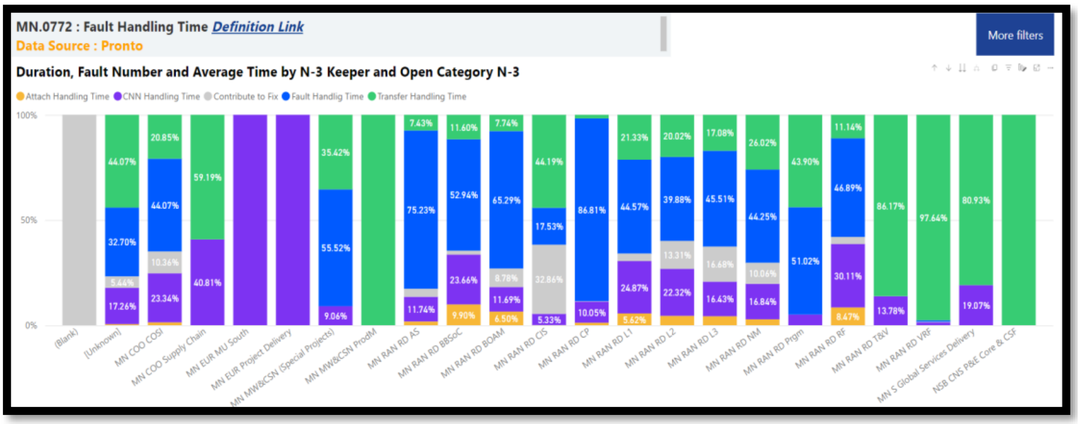

Figure 17: Fault Handling Time KPI Chart

In Figure 16 an example of an empty KPI dashboard can be seen. This was caused because of restructuring in the case company and changing the names of certain departments, causing the data to be lost in the system, and poor dashboard robustness and maintenance. Figure 17 shows a poor visualization of Fault Handling Time KPI. No decision can be taken out of that graph, the colour scale is not carefully chosen, and the comparison between departments on this KPI is of low importance.

The last identified weakness is of systematic nature. The list of monitored KPI's of each department and its correspondent targets are reviewed and chosen only once a year by the same department. As is explained in the next section, re-visiting a KPI system once a year is not enough to ensure its success.

3.6 Summary of the Current State Analysis

The objective of this thesis is to find suggestions that improve the performance of the fault management process, and the process current state analysis has pointed towards the KPI system that supports the process as the root cause for its underperformance. Because of this, the research and solution definition solely focus in the KPI system with the final aim to improve the functioning of the fault management process.

This is the list of stated weaknesses of the KPI system, for which literature research was done to find best practices that the case company could apply to fix the defective KPI system:

1. The KPI system monitors too many KPI’s related to the fault management process.
2. Many of the selected KPI’s are not relevant nor measure performance.
3. Many KPI’s are not aligned with company strategy or process critical success factors.
4. There are counterproductive KPI’s between different teams.
5. The internal R&D KPI system is too influenced by the customer external stakeholder.
6. KPI Dashboards are obsolete or have poor data visualization.
7. The average employee does not know about the KPI dashboards and does not use them regularly.
8. The KPI system, followed KPI’s, and its targets are monitored only once a year.

Next section explains the literature research done with the aim to find concepts and best practices that could help the case company target the list of weaknesses.

4 Best Practices on KPI System Definition

The current state analysis explained in the previous section points towards the KPI system of the fault management process as a main root cause for its underperformance. Relevant literature on performance measurement and KPI's has been consulted in order to define a set of improvement actions for the KPI system of the fault management process. Multiple practices, methodologies and approaches have been studied to extract potential improvement actions for the case company, and these are explained in this section. The resulting conceptual framework built through relevant literature was used to conceive the improvement guidelines later presented to the case company.

There is a significant number of authors writing about performance management, and KPI's. To narrow down the search for relevant literature, only sources relating operational performance management were consulted, avoiding the majority of books that focus on financial performance. Additionally, when it comes to operational performance management, only the sources of best quality that resonated best with the case company organization were consulted, as there was a high risk of being overflowed by too many information sources about a highly subjective concept such as the key performance indicator.

4.1 Overview of Performance Measurement

The Key Performance Indicator concept gained its popularity in business performance management practices around the 90s, transforming the way that businesses were applying their strategies. Some of the most renowned authors that converted KPI into a mainstream business concept are Robert S. Kaplan and David P. Norton. But the concept of KPI has kept evolving towards the needs of modern businesses, and it has evolved away from the belief of "What gets measured gets managed" or "What gets measured gets done", sometimes attributed to Peter Ducker. Modern literature on KPI's emphasizes how carefully organizations need to select KPI's, as these play a key role in their strategy implementation. Current best practices are rather aligned with the viewpoint that less is more, not everything that can be measured matters and not everything that matters can be measured.

The outcome of this section is a conceptual framework that has two sub-frameworks. The main one is KPI selection, which contains multiple practices on how to correctly define a set of KPI's to recover process performance. The second sub-framework is of general nature and contains certain practices to successfully manage an existing KPI system.

4.2 KPI Selection

The KPI Selection sub-framework answers to the question "how to select the right KPI's?". Choosing the right KPI's in an organization is a critical activity. A successful selection can uplift employee productivity and align the process to function with the company strategy. An erroneous KPI selection can significantly degrade business performance, confuse employees, and damage productivity. A great example of this is explained by Parmenter (2015: 44). Managers of a Hospital from the United Kingdom started monitoring how long it took for patients to be attended by a doctor since their registration, with the aim to reduce the waiting time of the emergency department. This resulted in the nursing staff requesting the paramedics to leave incoming patients in the ambulance until a doctor would be available, thus delaying patient registration and improving the KPI's of the hospital. Needless to say, this collapsed the ambulance service of the hospital.

The case company's fault management process does not directly have lives at stake, but this kind of unintended situation caused by careless KPI selection is visible. For example, the time that a test engineer takes to reply to an information request from a developer during the investigation of a Pronto is monitored as a KPI. This often pushes test engineers not to report a fault when they do not have enough resources to support the investigation at a given time and would not be able to reply to incoming information requests in a quick manner. Not reporting an identified fault in 5G software is damaging product quality, causing inefficient software management and can even degrade customer satisfaction if a customer would suffer the fault before it is fixed.

Three steps have been identified to select the KPI's that ensure the optimal performance of a process: Metric classification, KPI selection and KPI validation.

4.2.1 Metric classification

KPI's are selected from all the available metrics of the process. Proper understanding of these metrics is needed in order to choose the ones that should be monitored and will cause a positive impact on performance. The case company allegedly monitors 1110 KPI's related to the fault management process across multiple dashboards. This is of course not very wise, and it is the consequence of not understanding the difference between a metric and a KPI, or the different kinds of metrics that exist. Multiple metric classification approaches have been documented by different authors such as Eckerson, Parmenter and Kerzner. The three classification approaches share the same philosophy, not all metrics are equal, not everything that can be measured should be measured, and not all metrics can become KPI's. The three approaches are relevant, these are described next, and the case company was invited to choose from them as explained in section 5.

Eckerson (2010: 198-205) suggests the following four metric categories that could be relevant to the fault management process:

- Outcome metrics
- Driver metrics
- Actionable metrics
- Predictive metrics.

Outcome metrics, measure past activity that cannot be altered. These measure the output of the strategy but are not ideal for performance management as actions derived from these will not fix the performance of the monitored period. Driver metrics monitor the activities that will determine the outcome metrics. These are one step closer to present activity and are the critical ones for proper performance management. A subset of driver metrics is actionable. Actionable metrics can easily be impacted by management decisions. And last, predictive metrics are the ones that can be used to predict future results. These are very interesting for performance management, but its identification is challenging. Eckerson argues that a successful KPI dashboard should mainly include driver metrics, which are the hardest ones to identify. For this he suggests two methods: Five Why's and Sensory Perceptions methods.

Parmenter (2015: 4-15) describes these 4 categories to differentiate types of metrics:

- Result Indicators
- Key Result Indicators
- Performance Indicators
- Key Performance Indicators

In a similar way that Eckerson separates metrics as outcome or driver, Parmenter uses the concept of result indicator to classify a metric that measures past performance, while performance indicators are the driver metrics that influence future results. Reflecting to the case company, an example of result indicator would be the number of faults that are reported during a quarter or year. An example of performance indicator could be the accuracy ratio when reporting faults to a certain developer group. Then Parmenter also includes the Key label for these metrics depending on relevance.

The third documented classification approach is defined by Kerzner (2017: 129-138). He lists the following categories:

- Leading indicator
- Lagging indicator
- Diagnostic indicator

These categories are mainly divided into time frames. A leading indicator measures metrics that drive future performance, these would be referred to as predictive metrics by Eckerson. Lagging indicators measure past performance, so they would correspond to result indicators by Parmenter or outcome metrics by Eckerson. And diagnostic indicators measure present performance, so they could be compared to performance indicators by Parmenter or driver metrics by Eckerson.

It is clear that the three classification methods share a similar context, and significantly overlap, but each one still has its own nuances that might serve the case company better or worse. The selection process for a new metric classification method is described in section 5.

4.2.2 KPI selection methodology

Most authors agree on that choosing the right KPIs is the most important step for a KPI based performance measurement system because KPI selection determines the direction of productivity. A good selection makes sure that employees spend their efforts in alignment with the company’s strategy and allow managers to optimize process performance. But erroneous KPI selection can create employee burnout, poor process performance and unintended negative situations such as frictions between teams.

With the objective to improve the KPI selection of the fault management process, contributions from three different authors are studied and integrated. The importance of stakeholder and critical success factors identification from Kerzner (2017), the Winning KPI methodology by Parmenter (2015) and techniques for a KPI design workshop from Eckerson (2010).

Kerzner (2017:24-30) underlines the importance of stakeholder identification and proposes 5 main pillars to develop in project management, and how all these should be negotiated with all relevant stakeholders. Stakeholders greatly influence decisions, thus it's crucial to identify the stakeholders carefully because their selection affects the choice of KPI's. These pillars can be seen in Figure 18:

Figure 18: Project Management Pillars by Kerzner (2017: p24)

Figure 18 displays the five items that a project or process must define to ensure correct performance management. These are success criteria, KPI's, measurement technique, dashboard design and governance, and they must be agreed between stakeholders. Kerzner proceeds to explain that each stakeholder usually has a different definition of success, different requirements, is interested in different metrics and wants a different personalized dashboard. This is relevant to the case company's fault management process because of two reasons:

The fault management process supports both internal R&D faults, and customer faults. These are two very different activities, as one is making sure the product is ready for customer delivery, and the other is a service provided to customers to solve any potential fault in live networks. In the first activity, the customer is not a relevant stakeholder, although its objective is to ensure product quality to eventually improve customer satisfaction, but the customer is not an active participant of it. In the second activity, customer fault management, the customer is the most important stakeholder; thus, it is the customer that determines the process KPIs directly or indirectly. And what network operators value most when there is a fault in their live networks is how fast that fault is fixed. Most contracts between network providers like the case company and network operators around the world include financial penalties to the network providers dependant on how long live networks present a critical fault, so every minute counts when solving these faults. A significant set of the KPIs that monitor the performance of the fault management process in its entirety are time metrics. This seems to be aligned with the process success criteria for customer faults but is not aligned for internal faults which represent more than 90% of the cases. The combination of internal and external faults in the fault management process might be causing a wrong selection of KPI's. Reevaluating who are the actual process stakeholders will help to identify the real process critical success factors, and those will then derive into productive KPI's.

The other reason why stakeholder management is important for KPI selection is that a project or process manager should not give in to all wishes from every stakeholder. If every team participating in the fault management process follows the KPI's that they want, without proper coordination from governance, multiple scenarios where teams have counterproductive KPI's might appear, or even a team might monitor an unproductive KPI that is damaging its performance because it is not aligned with the process objective or company strategy. Process governance should select a finite set of process strategic KPI's, from which process stakeholders can choose.

Parmenter's (2015: 101-106) research on winning KPI methodology resonates deeply with the subject of this Master's thesis. The winning KPI methodology describes all the needed steps to establish a KPI system from scratch. The case company does already have a working system, so some steps might be skipped or adapted. Next figure shows the 12 steps of the original winning KPI methodology, and the estimated time required to implement a new KPI system:

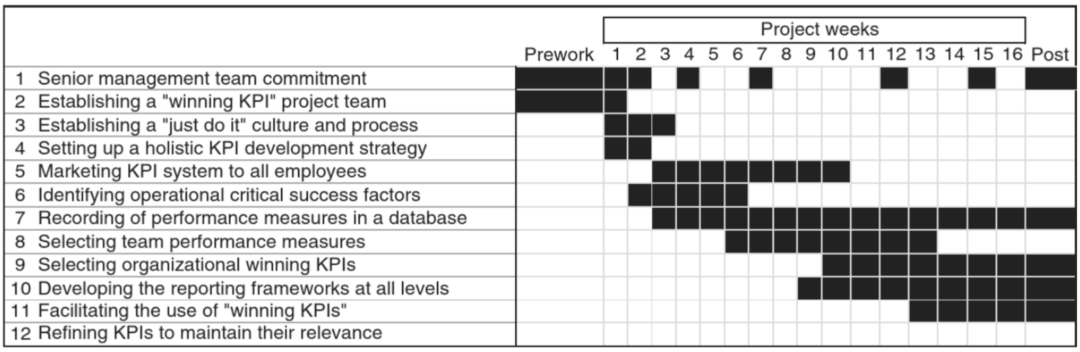

Figure 19: 12 Step Implementation of Winning KPI's by Parmenter (2015)

In Figure 19 the original Winning KPI's methodology and a time frame of implementation for mid-sized companies can be observed. These 12 steps will make it easier to understand the compacted 6 step version of this methodology that Parmenter published in the 3rd edition of his book:

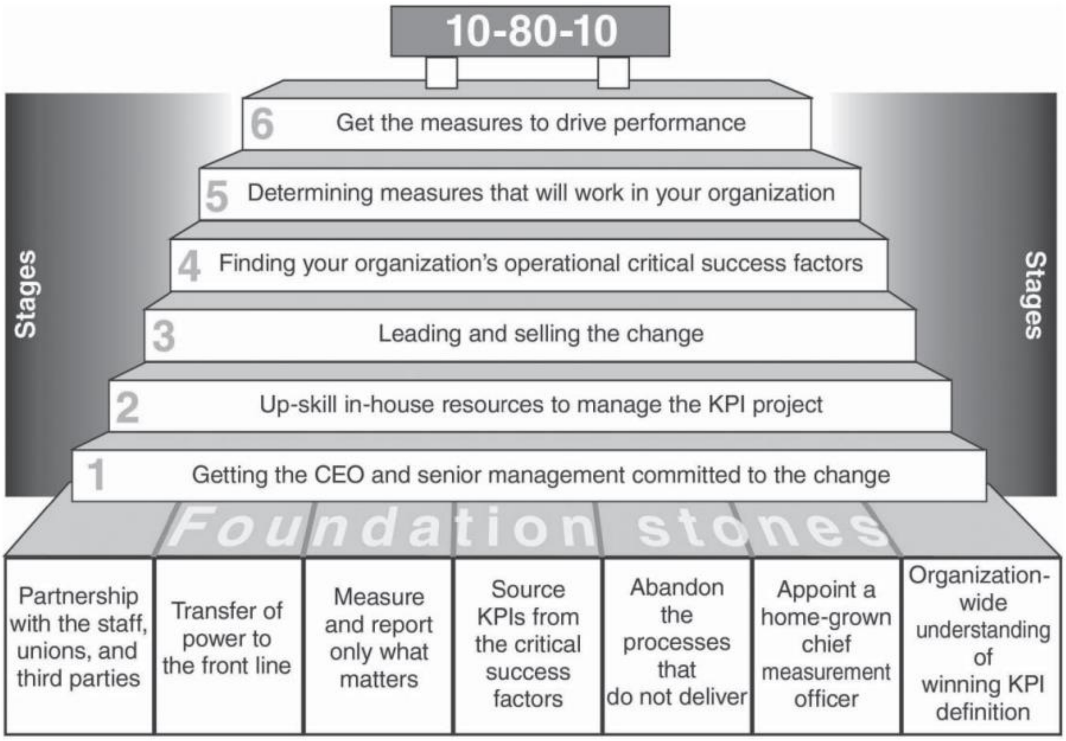

Figure 20: 6 Step Implementation of Winning KPI's by Parmenter (2015)

Figure 20 displays the methodology of Winning KPI's, the foundations stones for a successful KPI system and the 10 / 80 / 10 ratio of 10 Key Result Indicators, 80 Result and Performance Indicators and 10 KPI's that is explained later in this section. Some of the key foundation stones of the winning KPI's methodology that relate to the case company are:

- Measure only what matters (Lean reporting)
- Source KPI's from Critical Success Factors
- Appoint Chief Measurement Officer, or KPI system owner.

The 6 stages of the methodology are the following:

1. Getting the CEO and senior management committed to the change. For the fault management process of the case company Mobile Networks business group, it is not needed to reach chief levels of commitment for a meaningful change in its KPI system. N-2 support would suffice. But it is important to state that senior management of the company needs to be on board for the success of such initiative.

2. Up-skill in-house resources to manage the KPI project. The fault management KPI system in the case company is sustained by many quality managers that are local to their departments. A structure that oversees performance measurement externally from the departments is missing. Appointing a figure or team that would own the KPI system could potentially improve the health of the KPI system and consequently, the performance of the fault management process.

3. Leading and selling the change. The company culture should be aware and on board with a winning KPI system, so the workforce feels embraced and guided by the KPI's, instead of scared or careless about them. This cultural change would be achieved by top-down communication and multiple trainings.

4. Finding the organization's operational critical success factors. Critical success factors are the core of performance management. These are the operations that need to be properly executed and protected by

management to ensure the success of the company. CSF’s are usually referred to company level factors, and internal processes are just a subset of it. Parmenter (2015: 160) explains how to find the organization’s CSF’s, but for this Master’s thesis it is only necessary to identify the process CSF’s. Identifying the process CSF’s is of high importance because the CSF’s are the core successful activities of the process, and do not change with time, meanwhile KPI’s can differ from department to department, and be transformed through time. If all departments select the KPI’s to monitor based on the process CSF’s, KPI alignment should be achieved.

5. Determining measures that will work in the organization. The purpose of KPI’s is to ensure that the employees’ efforts are always aligned with the company’s strategy. For this reason, the KPI’s must be understandable and clear. Some recommendations in this regard by Parmenter are:

    - Limit the amount of KPI’s employees are exposed to.
    - Ensure that the selected KPI’s encourage the desired outcome and have no dark side.
    - Align the KPI’s with the operational CSF’s.
    - Use KPI’s to recognize and celebrate performance, besides monitoring incidents or risks.
    - Select the KPI’s by listening to a diverse group of employees in all possible dimensions.
    - Allow for continuous improvement of the KPI system to best adapt to the organization workforce.

6. Get the measures that drive performance. KPI’s should drive performance, and to do so, efficient dashboards should be accessible at all levels of the company. Teams should be trained on how to access and use KPI’s and its dashboards. These should be defined in a user-friendly manner, so that these motivate the workforce to perform and align their work with the company strategy on a day-to-day basis.

On top of Figure 20, the 10 / 80 / 10 rule can be seen. This rule states that an organization should have around 10 key result indicators, 80 result indicators and performance indicators and 10 key performance indicators. To link this to the nomenclature used by Eckerson, result indicators can be considered outcome metrics, and performance indicators can be driver indicators. The ratio suggested by Parmenter is completely subjective to the size and level of the operations of the organization, but its philosophy should be maintained. The KPI selection should be lean to ensure its effectiveness.

Eckerson (2010: 214) details a workshop strategy to efficiently build a performance dashboard. This workshop is intended to last 2 to 3 days and has 9 steps:

1. Frame: define strategic objectives.
2. Elaborate: elaborate the questions that the desired dashboard should answer about the strategic objectives.
3. Define metrics: select which metrics are linked to each question.
4. Define targets: specify targets and ranges for each metric.
5. Diagram drill paths: define the dashboard user paths.
6. Define behaviours: classify the metrics between outcome and driver metrics.
7. Check data: make sure that the selected metrics is backed up by available data.
8. Check for compliance and balance: ensure that there are no conflicting KPI's and that those cannot be worked around.
9. Assign owners: select owners for each metric.

Besides these 9 steps, Eckerson suggests leveraging existing metrics in the organization, given that any new metric an executive can think of is usually already being monitored. He also recommends that objectives should be the starting point of this exercise removing the focus from the metrics.

4.2.3 KPI validation methodology

The third step in the KPI selection sub-framework is KPI validation. Selecting the right KPI’s is not a trivial exercise, and should not be treated as one, and this is why multiple authors have described KPI validation methods and practices. Three contributions are listed below. A validation methodology by Eckerson, the characteristic checklist by Kerzner and the dark side of KPI’s concept from Parmenter.

Eckerson (2010: 218) provides a metric validation methodology next to his KPI selection instructions. This methodology consists of a weighted table to grade metrics that can be seen in Figure 21:

Measure	Linked to Strategy	Drives Behavior	Action-oriented	Easy to understand	Condition of Data	Standard Definition	Total
Weights	1.0	1.0	1.0	0.8	0.5	0.7	
Metric 1							
Metric 2							
...							
Metric N							

Figure 21: KPI Validation Weighted Table by Eckerson (2010: 218)

Figure 21 shows the table designed by Eckerson used to grade the quality of each metric on a scale from 1 to 5, with 5 being the highest score. It has been slightly adapted for the purpose of this Master’s thesis, while maintaining the author’s original essence. The intended way of using this table is to grade how aligned each metric is in 6 different weighted dimensions, and then do an average of these 6 dimensions to compute the quality of the metric. These 6 dimensions are: Linked to strategy, drives behaviour, action-oriented, easy to understand, condition of data and standard definition. The suggested weights by Eckerson should be considered, as he gives more importance to KPI alignment with strategy than comprehension or availability of measurable data for example.

The weighted table is a subjective method, but it can give insights to the case company on the quality of its KPI's and the potential dimensions where its KPI's are weaker.

Kerzner (217: 130) lists 12 characteristics that should define the selected KPI's. These are: strategic, simple, owned, actionable, timely, referenceable, accurate, correlated with business outcome, game-proof, aligned, standardized and relevant. These 12 important characteristics can also be considered when designing a metric quality measurement framework inspired from Eckerson's in Figure 21.

The dark side of KPI's is a concept brought up by Parmenter (2015). It describes the unintended consequences that some KPI's can cause in an organization, as employees might find workarounds for certain KPI's that eventually cause performance degradation, or even highly negative scenarios such as the one explained in KPI Selection section. To avoid selecting such metrics with a high risk of unintended consequences, an exercise should be done to review the selected KPI's, where the potential motivations and reactions to these by the employees should be estimated or even tested, and then discard any KPI's that could drive teams to have unproductive synergies.

4.3 KPI System Management

It has been stated above that the most critical step when building a KPI system is selecting the right metrics to monitor. This statement does not contradict that KPI system management is also of vital importance to ensure its success. Relevant literature has been reviewed to list best practices in this dimension that the case company might be not applying successfully. Three main practices have been identified: efficient dashboard data visualisation, effective monitoring of timely KPI's and continuous organization self-diagnosis to ensure high quality of the KPI system.

4.3.1 Effective dashboard visualization

Eckerson (2010: 218) states that correct data visualization is the enabler of performance monitoring dashboards to drive performance. Visually engaging charts and graphs empower users to identify anomalies and patterns, and to understand their impact in the company performance. A dashboard designed by a quality manager or similar, which can only be accessed, used, or understood by them, is a useless dashboard.

Modern businesses have been navigating through the Big Data era for decades, and the case company being one of the leading technology companies of the last 50 years is no exception. The company tools and data infrastructure allow to digitally measure virtually every ongoing activity, and particularly, the fault management process is accurately monitored by the Pronto tool. This one allows to measure every imaginable metric, generating gigantic volumes of data. Not everything that can be measured matters, but still, it is a strength of the fault management process to have such a capability. Then it is important to carefully select which of these metrics are KPI’s, and how the data is presented to the employees from all levels of the hierarchy in the organization. Stephen Few states that a successful dashboard should tell the user how to act with just a glance while having their morning’s coffee.

Eckerson shares a list of best practices on data visualization for dashboards:

1. The company should allocate visual designers to this task.
2. Know your users. Each dashboard should be adapted to its users, not only with content but also format and channel.
3. Dashboards should be designed with a lean approach. Less is more when it comes to data sharing.
4. The main screen of a dashboard should include all important measures, as the rest will be generally ignored.
5. Predefined layouts or templates are convenient for user experience.
6. Dashboards should be easily interactive by users with user friendly filtering options.

7. Data should be normalized and displayed in such a manner that comparisons are be easy.
8. Graphs should be designed without biases or agendas. Fair display of data will allow critical decision making.

All performance monitoring dashboards should be compliant with the above listed guidelines to ensure proper engagement with the company's workforce.

4.3.2 Effective time scale for KPI monitoring

Parmenter (2015: 19) classifies important metrics as performance indicator or result indicators. Result indicators are also referred to as outcome or lagging indicators, and represent the outcome of the performance of multiple teams and departments. Result indicators, and key result indicators (KRI's), are valuable and useful to make long term decisions at the organizational level, but performance is driven by KPI's as those give actionable insights to the management and employees.

For KPI's to be actionable, the time frame of these metrics should be limited to the present time. Figure 22 shows Parmenter's time frame recommendations for RI's, KRI's, PI's and KPI's:

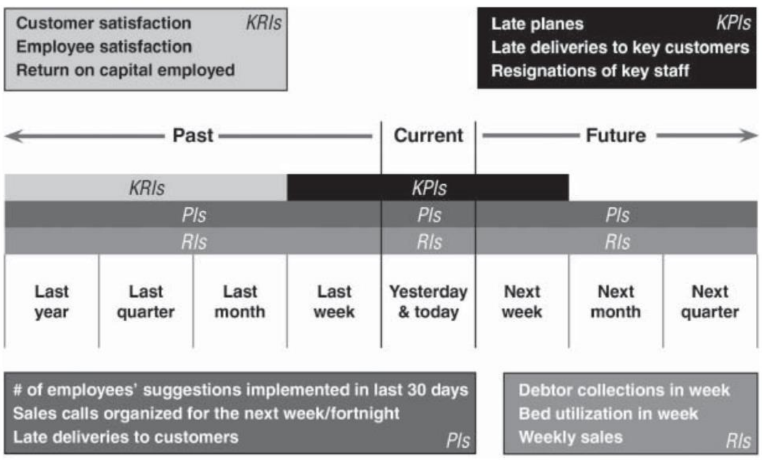

Figure 22: Time Scale Differences Between Measures by Parmenter (2015)

Figure 22 shows a recommended time range for different kinds of metrics. KPI's should be focused on the present time, the past week and the week ahead. Focusing the scope of KPI's to present time allows for actionable measures based on its interpretation. Constant attention to measures that monitor the activity of the whole year might be of value to the company leadership, but not so useful for employees lower on the hierarchy or direct managers, as those results cannot be retrospectively improved. KPI's are not intended for performance reviews, they should tell employees what to focus on next.

4.3.3 KPI system self-diagnosis

Building a KPI system is not a one-time effort, it is a permanently ongoing process that organizations should commit to. Parmenter (2015: 23) describes a set of 15 questions that assess the health of a company's KPI system. This set has been adapted to 10 relevant questions for this Master's thesis that can be seen in Figure 23:

Assessment questions		Is it covered?	
1	The organization has identified the CSF's	YES □	NO □
2	Senior management has common understanding of the organizations CSF's	YES □	NO □
3	The CSF's have been communicated to all staff and are used to focus priorities on a daily basis	YES □	NO □
4	Performance measures have been derived from CSF's	YES □	NO □
5	All measures are carefully monitored to ensure they promote appropriate behavior	YES □	NO □
6	Teams monitor their performance measures	YES □	NO □
7	Senior management reviews performance measures monthly or more frequently	YES □	NO □
8	Leadership is focused on KPI's and contacts stakeholders to rectify identified issues	YES □	NO □
9	There are less than 10 KPI's in the organization	YES □	NO □
10	KPI's are not linked to employee compensation	YES □	NO □

Figure 23: Adapted KPI System Assessment Questions by Parmenter (2015)

Figure 23 shows the questions that the governance of the fault management process should answer to evaluate the health of its current KPI system, and periodically revisit its results to make sure the planned improvements are implemented successfully.

4.4 Summary of the Conceptual Framework

This section includes the summary of contributions to the conceptual framework of this Master's thesis, focused on how to improve the KPI system of the fault management process, shown in Figure 24:

Improvement areas	Key subjects	Contribution	Source
KPI Selection	Understand the Process Metrics	Outcome, Driver, Actionable and Predictive Metric Classification	Eckerson (2010: 198-205)
		Result Indicators vs Performance Indicators	Parmenter (2015: 4-15)
		Leading, Lagging and Diagnostic Metric Classification	Kerzner (2017: 133-138)
	Select the Right KPIs	Winning KPI Methodology	Parmenter (2015: 101-106)
		KPI Design Workshop	Eckerson (2010: 214)
		Stakeholder Identification	Kerzner (2017: 24 – 30)
	Validate the KPI Selection	KPI Validation Methodology	Eckerson (2010: 218)
		KPI 12 Characteristics Checklist	Kerzner (2017: 130)
		The Dark Dide of KPIs	Parmenter (2015)
KPI System Management	Build comprehensive Dashboards	Effective Dashboard Displays	Eckerson (2010: 218)
	Choose Effective Time Scale	Effective Time Scale for KPI monitoring	Parmenter (2015: 19)
	Self-Diagnose Periodically	Performance Monitoring Quality Checklist	Parmenter (2015: 23)

Figure 24: Conceptual Framework Summary

Figure 24 shows the two sub-frameworks built to improve the KPI system of the fault management process of the case company, KPI selection and KPI system management. The KPI selection sub-framework consists of the classification, selection and verification of KPI's and it is the main pilar of the literature research. KPI system management includes some best practices to ensure the success of the KPI system, including Dashboard visualization, timely monitoring of KPI's and system self-diagnosis practices.

The completed conceptual framework is used in the next section to conceive improvement guidelines for the KPI system of the fault management process.

5 Building a Successful KPI System

The objective of this master’s thesis is to define a set of suggestions for a successful KPI system that improves the performance of the fault management process of the case company. In previous sections, the current state analysis of the process and its KPI system has been described, and findings in relevant literature listed. This section explains how the findings of the current state analysis and best practices from relevant literature are combined to conceive an initial proposal for a successful process KPI system.

5.1 Overview of the Proposal Building Stage

In order to define a set of improvements that best resonate with the case company’s business problem, a workshop with relevant stakeholders from the organization took place. The objective of this workshop was to adapt the set of best practices identified to better suit the business problem at matter. The workshop started with a problem statement, where the conclusions from the current state analysis of the process and KPI system were explained. Then the recommendations and best practices from relevant literature were discussed in a manner that would allow inputs and feedback from the workshop participants. The insights from the participants were then used to build a robust initial proposal of improvement suggestions.

5.2 Initial Proposal

After reviewing the conclusions from the current state analysis during the introduction of the workshop, a general view of improvement actions was presented as can be seen in Figure 25:

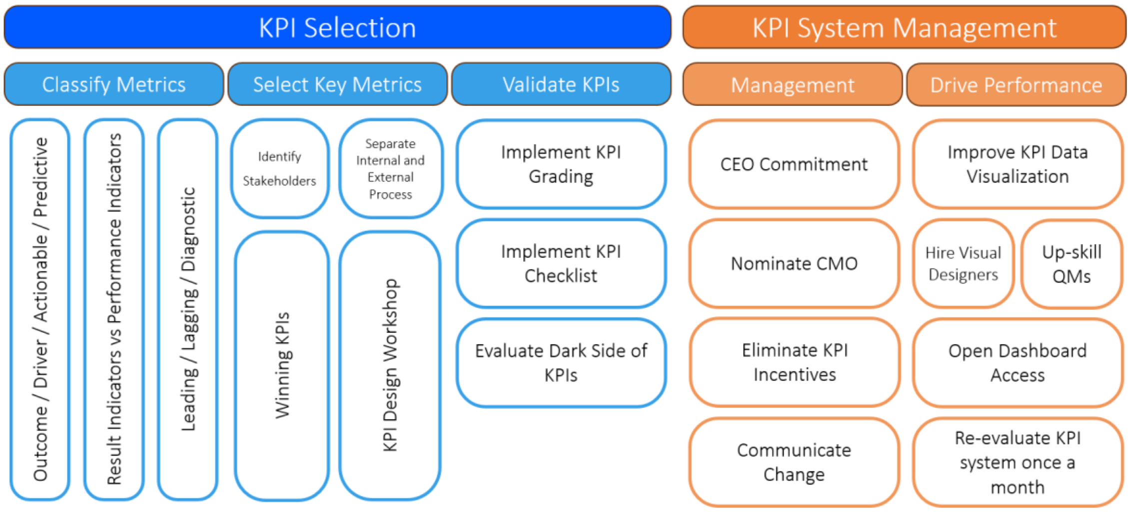

Figure 25: Input for the Initial Proposal

Figure 25 displays the list of improvement actions that the workshop discussed about, choose from, and adapted to best serve the business problem of the case company. Improvement actions are divided into two categories, KPI Selection and KPI System Management. Each category presents a series of improvement areas that were addressed. Some of the items in Figure 25 are displayed in parallel, meaning that these were presented as multiple options that the workshop participants had to choose from. Items displayed in a vertical sequence were presented as standalone items during the workshop.

In the upcoming sub-sections, the workshop discussion and process that lead to the initial proposal are described, alongside the outcome of the workshop.

5.3 KPI Selection Improvement Actions

KPI Selection was identified as the most important activity when building a successful KPI system, and it covered three key areas:

1. Understanding and classification of metrics.
2. Designing and selecting Key Performance Indicators.
3. Validating Key Performance Indicators.

These 3 main subjects were identified during literature research. Senior management and relevant stakeholders involved with the fault management process need to understand the available metrics, as not all metrics should become KPI’s, and not everything that can be measured should be measured. Best practices on how to then define and select KPI’s should be incorporated to achieve a new and successful list of KPI’s. And last, to make sure that the KPI selection is successful, different recommendations on how to best validate a list of KPI’s were discussed.

5.3.1 Improvement suggestions for metric understanding

In order to best understand metrics, the workshop chose from three different metric classification frameworks.

1. Outcome, Driver, Actionable and Predictive metrics by Eckerson (2010: 198-205)
2. Result Indicators and Performance Indicators by Parmenter (2015: 4-15)
3. Leading, Lagging and Diagnostic metrics by Kerzner (2017: 133-138)

The three classification frameworks share the same spirit, not all metrics are equal, and not all can become KPI’s. Eckerson says that only actionable and predictive metrics can become KPI’s, Parmenter goes one step further and already calls these metrics performance indicators, and Kerzner classifies metrics that can become KPI’s as leading indicators.

Parmenter’s classification is the one that resonated the most with the workshop participants, because of its simplicity, lack of negative tags such as “lagging indicator”, and because it was stated that most of the KPI’s that are monitored about the fault management process are in fact result indicators. Thus, a transition to this new classification framework should not require a significant effort but would transform the current understanding.

Elaborating on Parmenter's classification, the new metric types would be result indicator, performance indicator, key result indicator and key performance indicator, depending on measure and relevance.

5.3.2 Improvement suggestions for KPI selection

The first topic raised when discussing about KPI selection or KPI design was the internal and external nature of the fault management process, and how this creates a conflict in its KPI system. Customer stakeholder should not have a significant influence in all the faults that go through the fault management process, while only 5% to 10% of these are reported by customers.

Two improvement suggestions were presented. One option is to separate the process for internal and external faults. This suggestion was immediately discarded after the workshop participants argued that creating one new process of such dimensions would be a costly operational transformation. Then the second option was chosen, that consists of clearly identifying the stakeholders that the KPI system is serving and distinctly separating the KPI measurements from internal and external faults.

After clearing the internal and external conflict of the process, two methodologies regarding KPI selection were discussed, Winning KPI's methodology by Parmenter (2015: 101-106) and KPI design workshop by Eckerson (2010: 214), described in the previous section. Both methodologies are of general nature, so a new 8 step KPI selection project was defined based on adaptation of steps recommended by each author, while discarding the steps of lower relevance. Figure 26 shows the overview of this 8-step project:

Figure 26: KPI Selection Project of the Initial Proposal

In Figure 26 the 8 steps for KPI selection that were defined as crucial during the workshop are listed. Get senior management commitment is necessary to conduct a new KPI list and KPI System, for both the leadership guidance and to get the needed resources. A KPI System Owner team should be appointed as responsible of the KPI system that is external to the fault management process and does not belong to any of the process stakeholders. Senior management should identify the critical success factors of the fault management process, taking into account the relevant stakeholders and the recommendation to exclude customer influence from the KPI's. Once the CSF's are defined, the KPI System Owner team should define the operational level KPI's of the process. The recommended number of KPI's at process level would be a maximum of 10, based on Parmenter's recommendation for mid-sized companies, based on this, quality Managers of each department should select up to 5 KPI's from the previous list, adapting the metric source to their department. Each KPI should have an owner per department, and estimated targets for these should be defined as estimation exercise. As a last step, also conducted by the quality managers, the approved KPI's should pass the validation checklist that is described in the next section.

5.3.3 Improvement suggestions for KPI selection validation

As stated previously, KPI selection is the most important step when building a successful KPI system, and it is a significant responsibility in the organization. KPI's should be the compass that guide all employees towards fulfilling the company's strategy. Too many KPI's will have the employees walking in circles, while erroneous KPI's will have employees walking in the wrong direction. Because of the importance of KPI selection, an additional validation step was added. For this, three items were reviewed during the workshop.

The first KPI validation method discussed was the KPI Grading System by Eckerson (2010: 218). This one was discarded because of the high subjectivity of the grading system.

Next, the KPI checklist by Kerzner (2017: 130) and the concept of the dark side of KPI's by Parmenter were scrutinized. The idea of a checklist was well perceived, so a new 10 step checklist inspired by Kerzner's work was defined. Figure 27 shows the new 10 step check list.

Figure 27: KPI Validation List Defined during the Workshop

Figure 27 shows the 10-step checklist that any KPI should pass without exception when being selected for monitoring. This would highly increase the chances of success of a new KPI system, and simultaneously expose the state of the current KPI system.

This concludes the topics discussed during the workshop regarding KPI selection. The improvement ideas on metric understanding, KPI selection and validation were added to the initial proposal, and then the workshop focused on successful KPI system management.

5.4 KPI System Management Improvement Actions

It has been stated multiple times during this thesis that selecting the right KPI's for an organization is the critical step when building a successful KPI system, but still these need to be enabled through proper KPI system management. During the second half of the workshop, various improvement ideas related to KPI system management were discussed in a similar manner than the KPI selection improvement areas.

5.4.1 Improvement ideas for KPI system management

The first recommendations under discussion were related to who should be the main driver and responsible of a change of such proportions in the KPI system in the case company. Authors such as Parmenter recommend getting the CEO of the company on board and appointing a Chief Measurement Officer to ensure the presence of KPI driven performance in the company. These two ideas were discussed and toned down during the workshop. The case company is a large multinational constituted by four Business Groups that virtually behave as 4 different companies. Hence, CEO involvement would not be necessary. The fault management process takes place inside Radio Access Networks R&D organization in the Mobile Networks Business Group. Involving the head of RAN

R&D would suffice to drive the proposed initiatives. This translates into getting N-2 approval inside the company.

Following the same logic, it was argued that appointing a new CMO would not be necessary, but the idea of building a KPI System Owner Team that would report directly to the head of RAN R&D was well received. This Master's thesis is focused on improving the performance of the fault management process, but once that would be done, the KPI System Owner Team could also expand their responsibility to the overall organization KPI System, as most probably there are more cases of unsuccessful KPI systems in the case company.

Another management decision that was evaluated was to eliminate KPI related bonus incentives in the departments involved in the fault management process. Most authors suggest that this motivates employees to work around KPI's to maximise their bonuses, and this can be significantly detrimental to the organization specially if the KPI selection is not optimal. The decision on this improvement idea was not conclusive. It was argued that as the case company operates in dozens of countries with different cultures, each site should be able to decide how they incentivise their employees. So, this improvement action would only be given as a recommendation but not an imposition. Reflecting on the workshop conclusions, probably this recommendation was not so well received because of the still misunderstanding of what a KPI should be. Incentives can be linked to result indicators, but should not be tied to performance, but the employees of the case company still need to do the mind shift that not all metrics are performance indicators.

How to communicate this change, the new KPI system and KPI driven performance culture was discussed. At the moment, KPI's, targets and performance measurement are owned by quality managers, and these do not reach the workforce front line. The improvement in the KPI system should go hand in hand with a culture shift in the organization so that employees feel guided and motivated by the KPI system, instead of distracted or afraid. The importance of communicating a new KPI system was shared amongst all participants of the workshop, and few suggestions such as all-hands presentations and communication strategies were discussed, although the specifics of these are not in the scope of this master's thesis.

5.4.2 Improvement ideas for driving performance

Further practices were discussed to ensure that a new KPI system would improve the fault management process. These are related to the employee's exposure to the KPI system. As has been stated before, dashboards are not commonly used by employees in the fault management process, and many of these dashboards are unknown to anyone except for quality managers, some are obsolete and many present poor data visualizations. When presenting examples of poor data visualization charts, all workshop participants agreed that the quality of the dashboard needs to improve. Figure 28 shows a chart shared during the workshop present in one of the main dashboards of the fault management process. Figure 29 displays the same data, with improved data visualization techniques.

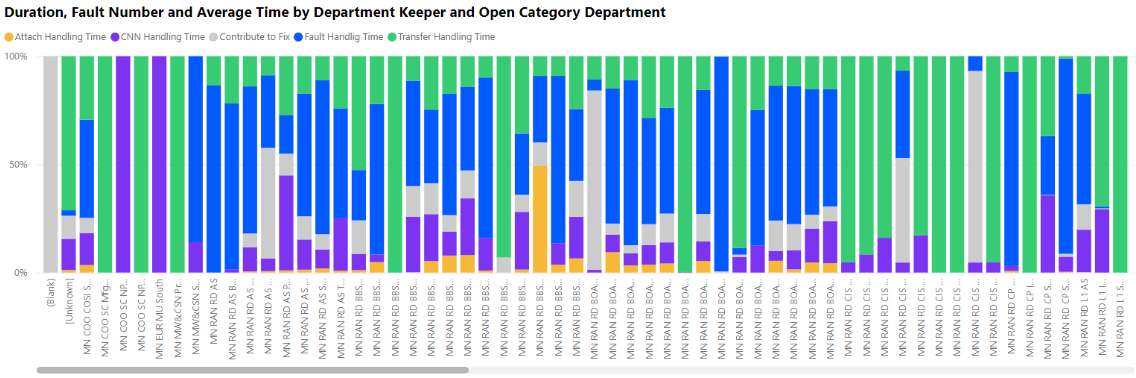

Figure 28: KPI Chart of the Case Company

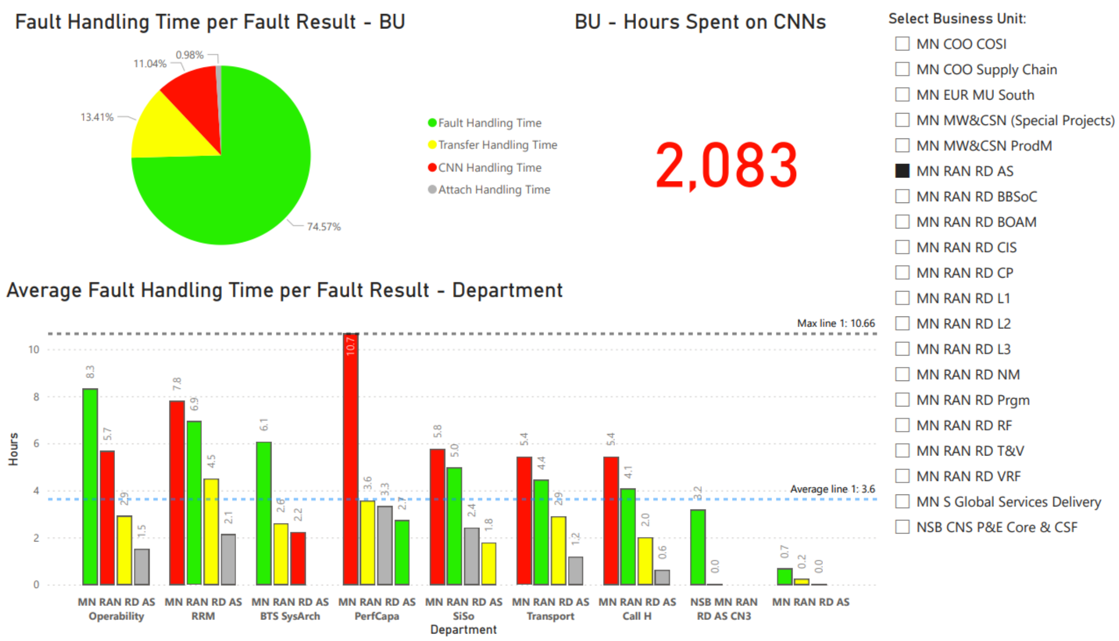

Figure 29: Improved Version of Figure 28 Chart

Figures 28 and 29 were presented during the workshop, as examples of the poor data visualization of used KPI charts, and to show that these can be easily improved. To make sure that the visualization and dashboards improve, two suggestions were given. The case company could hire qualified visual designers as Parmenter suggests or train the employees that are building and maintaining these dashboards. As the case company is at the moment going through a cost reduction campaign, the second option was chosen as it would require significantly less budget. Quality managers responsible of KPI dashboards should be trained on good data visualisation practices and on Microsoft power BI usage, the main tool used for this purpose in the case company.

Once the KPI dashboards of the fault management process would be in good shape, then these should be shared amongst all employees that participate of the process so that employees can easily understand the KPI's, and these can guide and improve productivity. As Eckerson suggests, employees should be able to figure out what do they need to do in less than 5 seconds when looking at a KPI dashboard while having their morning coffee.

As closure for the workshop, how often should the KPI system be re-evaluated was discussed. Currently, most departments chose the followed KPI's and respective targets once per year, when setting their yearly goals. It was presented that most authors recommend re-visiting the KPI system at least once a month by senior management, and this was perceived as too often and requiring too much effort due to the process scale. While discussing multiple options, it was argued that re-evaluating the KPI system once per release would be a good cadence for the case company. The number of releases per year vary between 2 and 4, so the KPI system would be re-evaluated every 6 to 3 months which is a considerable improvement.

5.5 Summary of Initial Proposal

After the fruitful workshop discussion, the initial improvement proposal to build a successful KPI system that improves the performance of the fault management came into shape. Figure 30 shows the resulting initial proposal.

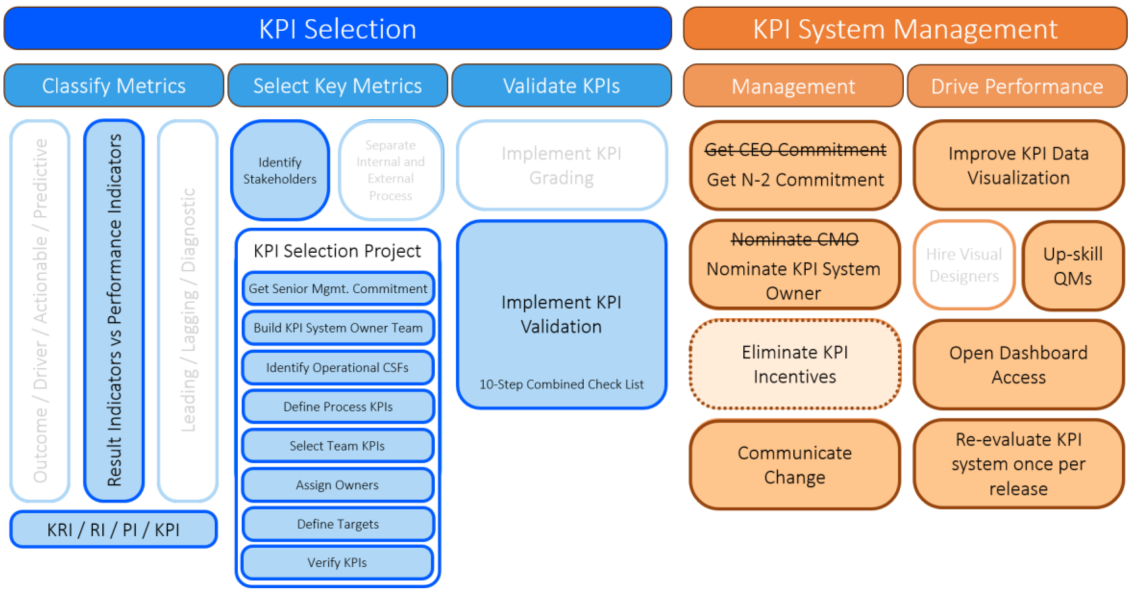

Figure 30: Initial Proposal

Figure 30 visually displays the result of the initial proposal workshop. Improvement suggestions that were selected are highlighted, while discarded items are faded. The summary of improvement suggestions is:

1. Classify metrics into Key Result Indicators, Result Indicators, Performance Indicators and Key Performance Indicators.
2. Identify relevant stakeholders of the internal R&D KPI System and remove customer influence in the KPI selection process.
3. Execute the 8-step KPI selection project to define an effective list of KPI's at process and department level.
4. Follow the 10-step KPI validation checklist before accepting KPI's.
5. Get commitment from RAN R&D Head and nominate a KPI system Owner Team reporting directly to N-2.
6. Communicate KPI System change and KPI driven performance culture.
7. Improve KPI data visualization and dashboards and share them with the entire workforce.
8. Re-evaluate the KPI System once per release.

This proposal still went under further scrutiny and validation through a series of interviews explained in the next section.

6 Final Proposal Validation

The initial proposal was built by following an applied research approach after conducting the current state analysis, consulting relevant literature and interviews and workshops with relevant stakeholders. Potential flaws in the applied research method, for example selecting a non-representative subset of process stakeholders, or false initial premises, could lead to erroneous conclusions and a defective solution proposal. This is why a validation stage was conducted with relevant stakeholders that had not yet been consulted during previous stages of this Master's thesis. The validation stage and its outcome are explained in this section.

6.1 Overview of the Validation Stage

The validation approach to the improvement suggestions for the KPI System of the fault management process consisted of three 1 to 1 interviews with key stakeholders. During these interviews, the problem statement and the initial proposal was presented with the aim to collect feedback and insights that made the solution proposal robust and bullet proof for it to be presented to the head of RAN Verification and Head of RAN R&D. The three interviews were conducted with a senior quality manager, a strategic program manager and a transformation manager.

These three different roles were chosen for the following reasons. The senior quality manager directly works with the fault management process and is highly experienced in the ongoing KPI system of the company, so she was able to give a highly credible assessment of the solution proposal and its content. The strategic program manager, while not being directly related to the fault management process, was able to give strategic advice to the proposal and assessment if this initiative is in line with the direction the case company should go towards. The transformation manager gave highly valuable feedback on how to best present the proposal to ensure higher chances of success and leadership approval.

6.2 Feedback on the Initial Proposal

The findings and solution proposal presented to the relevant stakeholders was extremely positively perceived. The current state analysis of the fault management process and its KPI system was described as eye-opening and highly relevant for the company's operations. The co-created solution proposal with relevant stakeholders, backed up by relevant literature practices was perceived as the right way to address all the listed problems of the process and KPI system. Despite most of the feedback received during the validation stage being positive, special attention is given to the insights that made incremental improvements to the proposal before it was presented to the case company leadership.

The first interview was conducted with the strategic program manager, who provided highly favourable feedback regarding the initial proposal. He described the findings from the CSA as enlightening and of high importance, the solution proposal was robust and well targeted to correct all the identified weaknesses. He urged to share the findings of this Master's thesis and the solution proposal to the company's leadership as soon as possible, due to the criticality of the business problem for the company's operations. In order to ensure the proposal is well understood by leadership, he brought up the following points: The proposal should give a clear recommendation on how many KPI's should be defined at process and department level, alongside a clear hierarchy scheme between KRI's and KPI's. When presenting the proposal to leadership, the unintended situations caused by the current flawed KPI selection should be highlighted, alongside the perceived lack of strategic alignment and critical success factors of the fault management process.

The second interviewee was the senior quality manager. Her abundant experience on the fault management process and the KPI system was of high relevance for the validation of the proposal. She agreed with all the findings of the current state analysis. She was already aware of some of the identified flaws of the KPI system, while others were described as eye-opening. She was very interested in presenting the solution proposal towards leadership, with the hope of improving the current state of the fault management process and she mentioned that such proposal could be received by a considerable degree of resistance from middle management. She recommended executing a scaled down version of the solution proposal at department level, as she could foresee multiple benefits already although that would not be able to strategically align the KPI’s of all the departments that interact with the fault management process.

The third interview was with a transformation manager in order to gain the point of view of a professional experienced in leading change projects in the organization. Besides multiple compliments to the research approach, the findings and solution proposal, he gave a series of recommendations to increase the chances of success of the proposal. Before presenting the solution to leadership, local sponsors of multiple departments should be found and convinced of the change. When presenting the proposal, the difference between the current way of working of the KPI system and the proposed one should be explained very clearly. The drivers and owners of each action suggested by the proposal should be well defined. The proposal should be presented in a modular format, so that some pillars of it can be applied even if the complete solution proposal is not adopted by the case company. He also expressed the high potential and easy implementation of the KPI 10-step validation checklist and the suggested result indicator vs performance indicator classification improvement actions.

6.3 Final Proposal: Suggestions to Build a Successful KPI System

The three key stakeholders provided highly favourable feedback to the initial proposal, which did not get significant content modifications during the validation stage. Their recommendations and tips mainly contributed to improving how the solution should be presented to the case company leadership, in order to convince them that the performance of the fault management process can be significantly improved by building a successful KPI System as described in the final solution proposal. The main recommendations followed concerning the content or format of the final solution are to suggest a clear number of KPI's to be followed at process and department level, to suggest improvement actions in a modular format and to clearly define responsibilities of each improvement action. By following these recommendations, the format of the final solution proposal can be seen in Figures 31, 32 and 33.

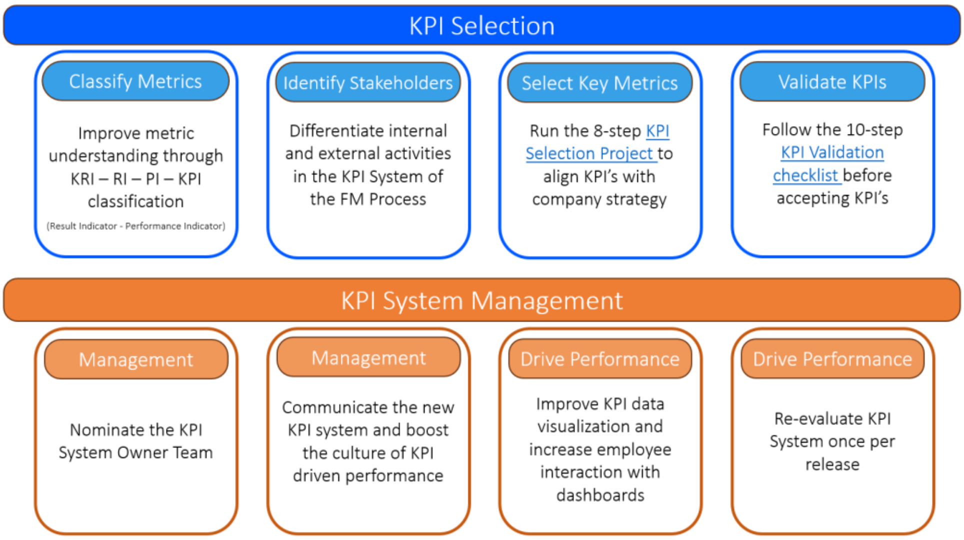

Figure 31: Final Improvement Suggestions Proposal

Figure 31 shows the 8 improvement actions that the case company should take to build a successful KPI System that would directly improve the performance of the fault management system. 4 actions are related to KPI selection, and 4 actions related to KPI System management. All of these are interconnected but can also be applied separately as partial improvements, in case the case company would not pursue the complete solution proposal.

Activity	Senior Management	Quality Managers	KPI System Owner	Middle Management
Build KPI System Owner Team	A	R	R	I
Classify Metrics – KRI, RI, PI, KPI	I	C	R	I
Coordinate the KPI Selection Project	C	C	R	I
Identify Process CSF's	R	C	A	I
Define Process KPI's	C	C	R A	I
Select Department and Team KPI's	I	R	A	C
Assign KPI Owners	I	A	I	R
Set KPI Targets	I	R	R A	C
Validate KPI's with KPI Checklist	I	R	A	I
Improve Data Visualization and Power BI skills	I	R	A	R
Improve Dashboard Visualization	I	R	A	I
Communicate new KPI System	A	R	R	R
Re-evaluate KPI System periodically	I	R	A	C

Figure 32: Improvement suggestions RACI Table

Figure 32 details the RACI roles of each action included in the improvement suggestions list. “R” stands for Responsible, “A” for Accountable, “C” for Consulted and “I” stands for informed.

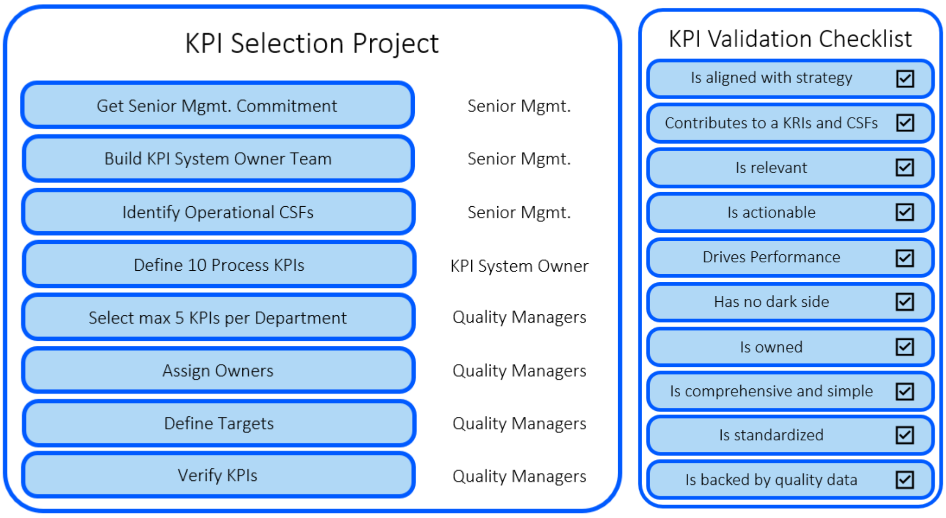

Figure 33: KPI Selection Project and KPI Validation Checklist

Figure 33 shows both the KPI validation checklist and the 8-step KPI selection project with detailed drivers for each step, both part of the final proposal solution and outcome of the initial proposal workshop discussion.

7 Discussion and Conclusions

This section encloses the Master's thesis by providing a comprehensive overview of the conducted project. It includes an executive summary that concentrates the created value of this report that hopefully will be of use for the case company and even other organizations with similar challenges, recommendations for next steps, self-evaluation of the completed research and solution conception, and closing words.

7.1 Executive Summary

The object of this Master's thesis is the fault management process of a leader network provider multinational whose main product is 5G networks. 5G is a cutting-edge technology that combines software and hardware, and as any software driven product, it is constantly evolving with new features and software improvements to keep the product ahead of the competitors. The case company sustains such a fast-paced development with a strong verification organization, whose purpose is to find faults during the development phase and correct them to ensure product quality before customer deployment. The verification organization is driven by the fault management process, which is not operating efficiently. Some symptoms of this are fault leakage to customer networks, slow fault correction and unproductive synergies between different teams participating in the process.

The ultimate goal of this Master's thesis is to find suggestions that improve the performance of the fault management process. This process is of high importance for the successful development mobile networks, a product that brings more than 10 bn EUR in yearly revenue to the case company, but also entails significant operating expenses. A four-stage applied research plan was defined to identify the weaknesses of the fault management process and design a tailor-made solution for the case company that can be applied immediately. These consisted of the current state analysis of the process and its KPI system, research of best practices relevant to the identified weaknesses during the current state analysis, initial solution design by adapting the relevant best practices to the case company and solution validation by key stakeholders of the case company. The applied research plan is described in section 2.

The first stage, explained in section 3, consists of the current state analysis of the fault management process. This investigation was conducted by consulting corporate documentation, an internal survey, interviewing relevant process stakeholders and organizing a workshop with process participants. Out of the identified weaknesses of the process, it was concluded that the KPI system of the process was the main root cause for its underperformance, and a second current state analysis of the KPI system unveiled its numerous weaknesses. The current system monitors too many KPI's, many of which are not relevant nor indicators of performance. Most of the monitored KPI's are not aligned with company strategy or process CSF's, and even create conflict between teams. The internal KPI system is influenced by customer definition of success, even if the customer is not involved in internal development activities, causing the internal KPI system to prioritize fault correction speed instead of product quality or efficient usage of resources. The KPI system is not properly supported by quality data visualisations nor dashboards, preventing a KPI-driven culture. And at last, the system, the monitored KPI's and its targets are reviewed only once a year.

Based on these findings, this Master's thesis focused on how to build a new and successful KPI system for the fault management process that would improve its performance. With this goal in mind, relevant literature was consulted to construct a conceptual framework of best practices regarding KPI selection and KPI system management. The main consulted resources were Parmenter (2015), Eckerson (2010) and Kerzner (2017), regarding metric classification, KPI design and selection, KPI selection validation, comprehensive KPI dashboard design, KPI-driven culture and KPI system management, all explained in section 4.

The findings of the literature research were shared with a select group of stakeholders of the fault management process. The information was presented in a comprehensive manner, that allowed to select the best practices amongst alternatives and to adapt general methodologies to best suit the problem at hand for the case company. This exercise is explained in section 5, whose outcome is the initial solution proposal. A set of suggestions on how to build a successful KPI system to improve the performance of the fault management process.

This set of suggestions was later presented to three key stakeholders, with the aim to validate the proposed solution and maximise its chances of success when applied to the case company. The three consulted professionals were a senior quality manager, a strategic program manager and a transformation manager. Following their feedback and recommendations, the final solution was presented in a modular format, and with clear responsibility defined for each step that the case company should take. The final proposal can be seen in section 6.

The outcome of this thesis is a compact and comprehensive list of actions that the case company should apply to build a successful KPI system that will improve the fault management process. The executive summary overview can be seen in the next Figure.

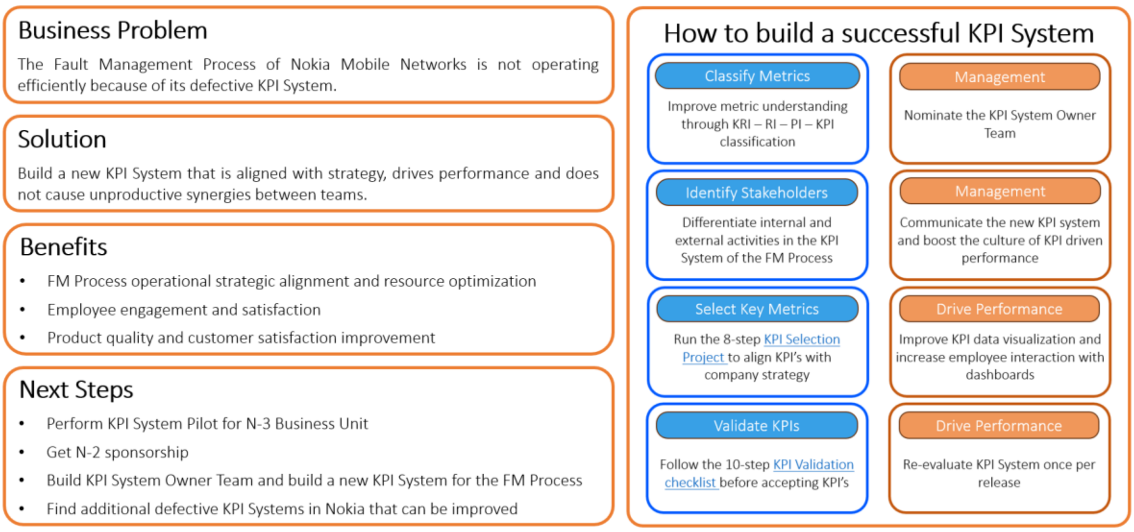

Figure 34: Executive Summary Overview

Figure 34 shows the executive summary overview, consisting of business problem, solution benefits and next steps. The benefits of building a new and successful KPI system around the fault management process would be process operational strategic alignment and resource optimization, employee engagement and satisfaction, and product quality improvement, ultimately improving the customer satisfaction. The fault management process of the case company is a critical process for the successful development of 5G and other mobile networks products, thus improving its performance would have a significant impact on the company performance.

To ensure that the findings and recommendations created during this Master's thesis would be of use for the case company, a set next steps are explained in the next subsection.

7.2 Recommendations for Next Steps

This Master's thesis reported a relevant business problem and conceived a solution to it using applied research methodologies and best practices from relevant literature. This project transcends the academic report, as the outcome of the thesis is a set of suggestions that are being brought forward to the case company and will potentially be applied in the near future. These ongoing and next steps are described in this section, although they are outside of the scope of the thesis.

After the validation stage described in section 6, the solution proposal was ready to be presented to the case company higher management. Following the recommendations of the consulted transformation manager, the solution was first presented to lower-level decision-makers that could sponsor this project to increase the chances of convincing the company leadership. The solution was first presented to a head of business unit, N-3 level. It was well received and discussed that this organization would run a pilot program following the guidelines to build a new KPI system. The proposed solution targets N-2 level organization in order to maximise its efficiency and strategically align multiple business units that participate to the fault management process, but running an initial pilot on a minor but considerable scale could then increase the chances of success at the long run.

The immediate next step is to run the successful KPI system pilot at N-3 level, and then if successful, using its momentum to get N-2 sponsorship, appoint an official KPI System Owner team and build a new KPI system following the proposal suggestions for the fault management system of the whole R&D organization of the case company.

If the next steps are accomplished, and a new KPI system for the case company R&D is build, then a monitoring of the performance of this system should be done during the following year, as this time window should be more than enough to evaluate the impact in performance of the fault management process of the new KPI system.

During the research of this thesis, evidence has been collected about the possibility of additional defective KPI systems in the organization unrelated to the fault management system. Because the object of this thesis is almost a perfect theoretical example of everything that can go wrong with a KPI system, the conceived solution proposal is complete and could be of used to improve general KPI systems in the case company. Thus, it is recommended to search for other KPI systems that could be improved in the case company, and apply relevant suggestions of this thesis to improve its performance.

7.3 Self-Evaluation of Thesis Project

There is two dimensions where a project can be evaluated, process and outcome, and usually they are intertwined. A well conducted project, that follows rigorous methodologies and logic, will have higher chances of success, and a successful project probably has been executed with an effective process.

The solution proposal outcome of this master’s thesis has been reviewed and will be applied to a business unit of the case company of considerable dimensions.

Hopefully this initial pilot will be successful and give enough momentum to the change initiative to get N-2 approval be applied to its entire R&D organization. This is the ultimate recognition of success that this thesis report could have, as it was done with the spirit to achieve a practical solution to a real problem. It is also symptom of the high standards and rigorous approach used during the thesis project, consulting numerous relevant information sources, and contrasting them, always asking the hard questions without being afraid of the answer, and with insistence to find the root cause of problems. This, combined with a humble approach when consulting relevant literature, has allowed to build an effective and robust solution to a very real problem happening in most modern companies, where performance lacks direction.

As stated during the thesis report, performance improvement requires awareness of what has been done right, and what should be improved. Applying this same philosophy to the Master's thesis, strengths and weaknesses of this thesis will be reviewed.

Starting with the thesis weaknesses or improvement areas, the significant amount of effort spend during the planning stage must be mentioned. The research approach and plan design has been revisited and changed multiple times, probably because the initial plan of this thesis report was done when the author was not familiar enough with the addressed business problem. This could have been improved by increasing the exposure of the business problem in the early stage of the thesis.

Another weakness of this thesis is the lack of cooperation from a highly relevant stakeholder of the fault management process, role of which will not be mentioned. This person's insights during the current state analysis stage would have been of high value, and would have reduced the needed time to gather all needed information. Expanding on this topic, it can be expected that any change management project that is aiming to do a meaningful change, faces some resistance by the established organization. Being rather optimistic, this lack of cooperation could be interpreted as a symptom of the importance of the change management project of this thesis.

Focusing now on the key strengths that have been essential for the success of the final solution proposal, the following points should be mentioned. The thorough root cause analysis during the CSA stage helped achieve a clear understanding of every weakness of the KPI system and that paved the way for the following stages of the thesis. It started shaping the solution proposal and guided the literature research through an extensive landscape of content regarding performance measurement. Also, during the current state analysis there was a key moment for the development of this project, the decision to focus on the KPI system of the fault management process in order to improve the performance of the process. This decision completely changed the nature of the thesis from business process development to performance management, and implied an increase in the research workload, but ensured that the real root cause of the problem was addressed thus making a relevant and practical solution. This decision, and other key decisions and observations during this thesis are backed by evidence, data and logical thinking, which is an essential characteristic of a high-quality research project. Another relevant quality of this thesis project was the humble approach to consult relevant literature, but bold attitude while choosing and adapting the best practices found to best serve the case company problem.

One last mention regarding the strengths of this thesis is that learnings from all the courses part of the Industrial Management Master’s program have contributed to the development of this thesis, so the program prepared the student with the necessary skills to address an ambitious challenge.

7.4 Closing Words

In current time, education and information availability have armed individuals and organisations with significant amounts of talent and skill. Despite this, many organizations struggle to bring this talent to good use because of lack of direction. Organizations usually opt for overengineering processes and periodical restructuring with the aim to find the key that will suddenly enable the optimal performance of their workforce, but many times, the answer rellies in the discrete dimension of performance management. This thesis project has understood that performance management is way more than performance measuring, it also includes organizational psychology and culture leveraging, employee engagement, motivation and satisfaction and true understanding and application of company strategy. All these concepts are the true enablers of successful operational performance, and this thesis has defined a set of guidelines on how to build a successful KPI system that embraces the best practices of performance management to recover the performance of a key process for the case company.

References

Atkinson, A. A., Waterhouse, J. H., & Wells, R. B. (1997). A Stakeholder Approach to Strategic Performance Measurement. *Sloan Management Review*.

Eckerson, W. W. (2010). *Performance Dashboards : Measuring, Monitoring, and Managing Your Business.* John Wiley & Sons, Incorporated.

Han, K. H., & Kang, J. (2007, September). A process-based performance measurement framework for continuous process improvement. *The International Journal of Industrial Engineering*.

Kananen, J. (2013). *Design Research as Thesis Research: A Practical Guide for Thesis Research.* JAMK University of Applied Sciences.

Kaplan, R. S., & Norton, D. P. (1996). *The Balanced Scorecard: Translating Strategy into Action.* Harvard Business Review Press.

Kerzner, H. (2017). *Project Management Metrics, KPIs, and Dashboards : A Guide to Measuring and Monitoring Project Performance.* John Wiley & Sons, Incorporated.

Marr, B. (2012). *Key Performance Indicators.* Pearson Business.

Parmenter, D. (2015). *Key Performance Indicators : Developing, Implementing, and Using Winning KPIs.* John Wiley & Sons, Incorporated.

Willaert, P., & Willems, J. (2006). Process Performance Measurement: Identifying KPI’s that Link Process Performance to Company Strategy. *Idea Group Publishing*.