TÉCNICO LISBOA

Internal Supply Chain Performance Management & Measurement Systems: Design for Implementation

The Case Study of VDL ETG

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Acknowledgements

"*Be daring, be different, be impractical, be anything that will assert integrity of purpose and imaginative vision against the play-it-safers, the creatures of the commonplace, the slaves of the ordinary*."

- Cecil Beaton

On February 2014 I made a trip to Eindhoven, The Netherlands to attend the career expo at the Technical University (TU). I had one goal, to develop my MSc Thesis abroad. Mixing in with the TU students, I talked to approximately 150 different companies and met Hilde Botden from VDL ETG. We stayed in contact for over one year and on the 9th of February 2015 I started my internship at Eindhoven. I will always express my profound feelings of gratefulness towards Hilde for believing in me.

"*One man may hit the mark, another blunder; but heed not these distinctions. Only from the alliance of the one, working with and through the other, are great things born*."

– Antoine de Sainte-Exupery

With this quote in mind, I acknowledge an extreme debt of gratitude to my supervisor Prof. Susana Relvas for her advice and foresight and to my company mentor Arno Vogels for challenging me on a daily basis and encouraging me to exceed every boundary established.

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Abstract

“Supply chain versus supply chain” is the new mantra for contemporary competitive businesses. To reach the desired competitive advantage and sustainability, companies are acknowledging the importance of supply chain management and the benefits of improving it by performance management and measurement systems. Combining supply chain management to these performance systems into supply chain performance management and measurement systems should enable enterprise quest in becoming business differentiators. There is a large gap in literature when it comes to merging these concepts, so this research aims at bridging this gap, providing a case study within the high tech industry. A supply chain performance management system framework is developed, together with a supply chain performance measurement system and the intent is to create awareness for further validation and development. The deliverable is the design for implementation of a Key Performance Indicator (KPI) dashboard which incorporates the measurement framework established, providing a high level integral overview of the case company’s performance allowing Management Team members to know where to focus and allocate resources in order to improve and ultimately reach their vision.

Keywords: Supply Chain Management, Performance Management System, Performance Measurement System, Supply Chain Performance, Key Performance Indicators, High Tech Industry

Resumo

"Cadeia de Abastecimento vs. Cadeia de Abastecimento" é o novo mote dos negócios competitivos mais modernos. Com vista a garantir a desejada vantagem competitiva e sustentabilidade de negócio, as empresas têm vindo a reconhecer a importância da Gestão da Cadeia de Abastecimento e dos benefícios da sua otimização através da utilização de sistemas de gestão e quantificação da performance. A combinação da Gestão da Cadeia de Abastecimento com estes Sistemas de Performance em Sistemas de Gestão e Quantificação de Performance da Cadeia de Abastecimento poderá auxiliar as empresas na sua busca pela diferenciação do negócio. Há uma falta de suporte literário no que toca à união destes dois conceitos, pelo que a presente investigação procura diminuir esta lacuna, através de um caso de estudo dentro da Indústria de Alta-Tecnologia. Foi desenvolvida uma estrutura adequada a um Sistema de Gestão da Performance da Cadeia de Abastecimento, em conjunto com um Sistema de Quantificação da Performance da Cadeia de Abastecimento. Como resultado pretende-se realçar a necessidade de posterior validação global e desenvolvimento de acordo com o negócio. O produto final corresponde ao estudo da implementação de um painel de Indicadores de Desempenho (*Key Performance Indicators*) KPIs que incorpora a estrutura estabelecida, providenciando uma análise completa do desempenho na empresa em estudo, o que permite aos membros do Departamento de Gestão focarem-se e alocarem recursos de maneira a melhorar o negócio e, em última análise, garantir a operacionalização da visão da empresa.

Palavras-Chave: Gestão de Cadeias de Abastecimento, Sistema de Gestão de Performance, Sistema de Quantificação de Performance, Performance da Cadeia de Abastecimento, Indicadores de Desempenho, Indústria da Alta Technologia

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List of Abbreviations and Acronyms

B2B – Business to Business
BSC – Balanced Score Card
BUs – Business Units
CC – Cost Controller
CLIP – Confirmed Line Item Performance
CoCoBo – Cost Control Board
CPR – Cost Price Reduction
CS – Customer Support
CTR – Cycle Time Reduction
EC – Engineering Change
EFQM – European Foundation for Quality Management
ERP – Enterprise Resource Planning
ETG – Enabling Technologies Group
FPY – First Pass Yield
FTE – Full Time Equivalent
High Tech – High Technology
HR – Human Resources
KPI – Key Performance Indicator
KPIs – Key Performance Indicators
MT – Management Team
NC – Nacalculati
NPIO – New Product Introduction and Optimization
NPL – New Product Logistics
OEM - Original Equipment Manufacturing
OEMs – Original Equipment Manufacturers
OV - Openstaande Verplichtingen
PAs – Performance Attributes
PDCA – Plan Do Check Act
PGP – Product Generation Process
PIs – Performance Indicators
PLCs – Product Life Cycles
PMa – Performance Management
PMC – Performance Management Cycle
PMe – Performance Measurement
PMeS – Performance Measurement System
PMeSs – Performance Measurement Systems
PMMS – Performance Management & Measurement System
PMMSs – Performance Management & Measurement Systems

PMS – Performance Management System

PMSs – Performance Management Systems

QBR – Quarterly Business Review

QLTC – Quality, Logistics, Technology and Cost

RLIP – Requested Line Item Performance

ROI – Return on Investment

SAIR – Supplier Assessment and Improvement Review

SAT – Strategic Advisory Teams

SBR – Strategic Business Review

SC – Supply Chain

SCEs – Supply Chain Engineers

SCM – Supply Chain Management

SCOR – Supply Chain Operations Reference

SCP – Supply Chain Performance

SCPM - Supply Chain Performance Management

SCPMeS – Supply Chain Performance Measurement System

SCPMMS – Supply Chain Performance Management & Measurement System

SCPMMSs – Supply Chain Performance Management & Measurement Systems

SCPMS – Supply Chain Performance Management System

SCPMSs – Supply Chain Performance Management Systems

SCs – Supply Chains

SMART – Strategic Measurement Analysis and Reporting Technique

TCO – Total Cost of Ownership

TQ – Total Quality

VC – Voorcalculati

VDL – Van Der Leegte

VMI – Vendor Managed Inventory

VMOI – Vendor Managed Own Inventory

WIP – Work in Progress

1 Introduction

This chapter serves as the first point of contact between the reader and the research *per se*. It provides all the information expected from a clear, robust introduction. Problem motivation is explained, followed by the objectives of this research, the problem statement and identification of the applied methodology for the study at hand. Next, this opening chapter provides the specific objectives and its corresponding research questions. This initial chapter ends off with the dissertation outline and by this point on, the reader should have gained enough insight of the matter and is ready to proceed to the next chapter, where the theoretical framework will be developed.

1.1 Problem Motivation

Globalization, new business models and an empowered customer and workforce have accelerated the pace of business beyond what seemed possible just five years ago. Because accurate and appropriate performance evaluation is critical for judging the success or failure of a business, performance indicators (PIs) that accurately reflect the competitiveness of a company must be carefully identified. The exclusive use of financial PIs encourages a focus on short-term results, but in today's complex global competitive environment, the incorporation of non-financial PIs, such as manufacturing capability, human resource management (Kao *et al.*, 2007) and supply chain integration, provides a clearer and more relevant picture of performance (Huo, 2012; Childerhouse *et al.*, 2011; Kim, 2006; Bagchi *et al.*, 2005; Maskell, 1989). Company executives have long been aware of the importance of their supply chains (SCs), but today, Business to Business (B2B) SCs are increasingly taking centre stage in the quest for greater profits and competitive advantage (The Economist Intelligence Unit, 2014). As the Global Supply Chain Survey, held in 2013 by PwC concludes, companies that acknowledge supply chain (SC) as a strategic asset achieve 70% higher performance and the ones that beat the competition on supply chain performance (SCP) also reach significantly better financial results. Henceforth, effective supply chain management (SCM) is treated as key to building a sustainable competitive edge through improved inter and intra-firm relationships (Ellinger, 2000). Business organizations need to capitalize on SC capabilities and resources to bring products and services to the market faster, at the lowest possible cost, with the appropriate product and service features and the best overall value (Gunasekaran *et al.*, 2004).

Continuously improving SCP has become a critical issue for most suppliers, manufacturers, and the related retailers to gain and maintain competitiveness (Cai *et al.*, 2009). In order to carry out this constant performance development, one must always acknowledge the following two aspects of performance *per se*: performance management (PMa) and performance measurement (PMe). Accordingly, and bearing in mind the well-known quote by Peter Drucker "you can't manage what you can't measure", PMa and PMe are not separable. They follow one another in an iterative process; management both precedes and follows measurement, and in doing so creates the context for its existence (Lebas, 1995). In other words, performance management systems (PMSs) encompass performance measurement systems (PMeSs), but not the other way around (Coveney, 2010).

Since PMe is important but not sufficient to manage an enterprise, there is a complementary need for a performance management system (PMS) (Melnyk *et al.*, 2013). Incorporating SCM and performance

management & measurement systems (PMMSs) into supply chain performance management & measurement systems (SCPMMSs) should catapult enterprise revenue and contribute extensively towards a business differentiator. In view of this, one would expect interest in developing management and measurement systems for managing SCP to be escalating, however, and as acknowledged further in this research, current literature lacks an adequate framework for the design of SCPMMSs and empirical cases of adoption experience are extremely limited in academic literature.

A suitable environment for a pragmatic case could be the high technology (high tech) industry since the nature of competition in this manufacturing industry has changed dramatically over the last two decades, and any of the traditional indicators of business performance are insufficient today (Tseng *et al.*, 2007). Furthermore, in order to maintain their competitive edges in the market, high tech firms cannot simply rely on superior technology alone (Wang *et al.*, 2012). For this reason, the high tech industry context presents itself as being particularly interesting for developing SCPMMSs as an empirical case. Paring this fact with the interest in investigating how this industry could take advantage of SCPMMSs to catapult its competitive position, presents enough incentive for this research.

All things considered, the problem motivation for this research is to bridge the gap between SCM and PMMSs at the high tech industry in current literature, by establishing useful up-to-date insight on how to successfully design internal SCPMMSs for implementation that are fit for this technologically advanced industry.

1.2 Research Objectives

This research aims to contribute to current academic literature by filing in the gap between SCM and PMMSs, which can serve as a basis for further theory development in the high tech industry. Configuring the supply chain to meet the needs of individual customers has proven to be a winning formula (Global Supply Chain Survey 2013 by PwC). Hence, the research does not aim to build a one-size-fits-all framework since PMMSs should always be derived from companies' specific vision and mission, which is clearly different for each firm (Gunasekaran *et al.*, 2004). Instead, it intends to define a tailored design of SCPMMSs and the configurations associated with its implementation. Findings are based on a case study within VDL Enabling Technologies Group (ETG), described more extensively in Chapter 4 and briefly presented in the subsequent section. This research will provide the case company with the best approach to the design for implementation of internal SCPMMSs that drive value maximization for the customer at the lowest possible cost.

1.3 Research Context

In order to get a proper view of the problem, one needs to know its context (Ichikawa *et al.*, 2014). VDL ETG is a tier-one contract manufacturing partner, operating world-wide in the high tech industry. Its customers include leading original equipment manufacturing (OEM) enterprises and users of advanced and sophisticated production lines. This close and direct involvement with OEM companies makes it a basic requirement for companies like VDL ETG to invest in the internal SC which connects them directly with their customers.

With manufacturing facilities in Eindhoven and Almelo (the Netherlands), Singapore, and Suzhou (China), the company has built a solid record in the following markets: semiconductor capital

equipment, thin film deposition equipment for photovoltaic solar systems, analytical instruments, medical systems, aerospace & defense parts and systems and mechanization projects.

Its services include engineering and prototyping - the prime activity for VDL ETG Research -, taking care of the product and technology development - the core of VDL ETG Technology & Development -, customer specific factory automation projects - the focus of VDL ETG Projects - and series manufacturing of 'high-mix low-volume' products, daily business in all other VDL ETG locations mentioned above. Herein, and unless stated otherwise, every time VDL ETG is stated, it refers to VDL ETG Eindhoven. The other three production sites are not included in the scope of this research since each facility has its own characteristics and specific structures.

It is of extreme relevance to make the reader aware that since the supply modules for the semiconductor industry represent a major part of VDL ETG's turnover, the company is highly subject to this business's economic pattern. A study named 'Semiconductor Supply Chains: An Urgent Need for Change' was conducted by Accenture in 2012 and asserts that device companies want semiconductors that support an escalating range of functionalities at ever shorter cycle speeds, and often fitting into even smaller form factors. Forster *et al.* (2013) present a clear overview of this industry, in Table 1.

Table 1: SC Characteristics in the Semiconductor Industry, Forster *et al.* 2013

Characteristics	Semiconductor Industry
Cyclicity and Volatility	Very High
PLCs and Innovation Cycles	12-18 Months
Supply of Spare Parts	Short
Quality Standard	High-Moderate
Lead Times	10-16 Weeks
Manufacturing Flexibility	Very Low

The authors point out that a distinctive characteristic of the semiconductor industry is its highly cyclical and volatile nature due to ever shorter market cycles with rapid growth periods, market slumps and innovation cycles - because semiconductors are most often integrated with sales periods of less than a year. Additionally, focus on technological progress is present; hence, product life cycles (PLCs) are short and similar to the PLCs of their customers, resulting many times in obsolete products.

New products are placed on the market every 12 to 18 months, with a service life of two to three years. Furthermore, this industry is not prepared to provide spare parts on a long-term basis since the innovation cycles are short making it possible to just offer this service for a limited time. Moreover, the semiconductor industry possesses a highly advanced level of quality and original equipment manufacturers (OEMs) have recently imposed more rigorous quality standards. However, there are some customers (e.g. from the telecommunications sector), that see quality as of secondary importance, since a few defective components can be ignored or routinely by-passed.

In terms of lead times, Huethorst (2011) identified that the normal lead time for the semiconductor industry is between 10 to16 weeks, which is considered extensive but it results from the fact that manufacture of chips is very complex and involves up to 800 process steps.

Likewise, as long lead times are a feature of the semiconductor industry, it operates on longer planning horizons, reaching up to six months. Finally, the last SC characteristic is 'manufacturing

flexibility' and the fact that the semiconductor industry seeks to achieve maximum utilization of its production resources with a 24/7 production schedule (Forster *et al.*, 2011), high qualification standards, an increase in labor division across several organization levels, and long lead times restrict the flexibility on the shop floor (Forster *et al.*, 2013).

1.4 Problem Statement

The following problem statement is specified, resulting from the problem motivation and from preliminary data gathering with key stakeholders, described in section 1.5.1.1 further on:

"How can successful internal supply chain performance management and measurement systems be designed for implementation at VDL ETG, driving overall customer value maximization at the lowest possible cost?"

1.5 Research Methodology

Verschuren and Doorewaard (2004) provide a broad, clear and goal-directed approach for a research design, represented in Figure 1. Firstly, the authors identify two distinct sets of activities: conceptual design, concerning all features that need to be achieved in the research, and technical design, regarding the *how* to attain them.

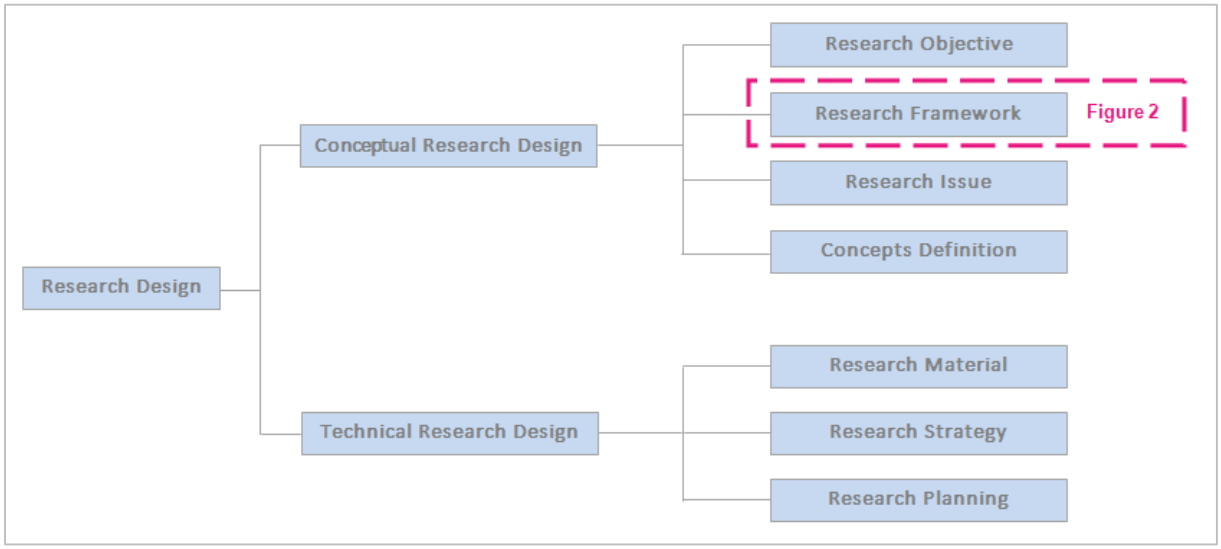

Figure 1: Research Design. Source: Verschuren and Doorewaard (2004)

1.5.1 Conceptual Research Design

The first set of actions, the conceptual design, refers to the *what*, *why* and *how much* the research will cover in terms of the problem presented. It consists of four components; to begin with, the *research objective* is originated, then the research structure will generate the *research framework* – represented later in Figure 2–, followed by distinguishing information that can provide valuable understanding towards achieving the research objective, the *research issue*. The last component of the conceptual design is the *concepts definition* where the key elements that comprise the research objective and research issue are defined and distinguished for the context of the research.

1.5.1.1 Research Objective

This has been already defined in section 1.2. The context of the research was identified by the conduction of semi-structured interviews with some key stakeholders, pointed out by the company mentor, in order to determine the set of problems which enabled the setup of the research and identification of the problem statement. Further information about the stakeholders and their participation/contribution to the detection of the issues can be found in Table 2. This section of the research objectives clearly states the purpose and utility of this study making it feasible within the timeframe of eight months (duration of the internship for master dissertation development purpose).

Table 2: Preliminary Data Gathering by Semi-Structured Interviews with Key Stakeholders

Key Stakeholder	Function	Main topics referred contributing to Problem Identification
Gerard van Wandeloo	Group Leader of SCEs	• For improvement we need SC integration • Focus on make-buy decision because this year VDL ETG is focused on costs • Focus on total cost of ownership - that's why VMOI is being implemented, so that operational costs of the factory can be reduced • Implement models/methods across the company over SC • The current SCM strategy is still valid but needs some adjustments. We are too occupied with daily activities for CPR and CTR and not looking at the bigger picture.
Christian Rademaker	Purchasing Manager	• Make SCM responsible for lead time at supplier – if SCM is responsible for their end customer, all logistic models are in place with all suppliers • 60% of parts are purchased – 20 people responsible, the rest (40%) – 350 people responsible. VDL ETG should focus on suppliers. Ratio is not balanced • Create a business case for each project that clearly states information like: profit, investment in hours, payback period, etc. if we were to invest in that project. This is SCE's responsibility • SCM strategy should be to contribute to enabling the SCP of the supply base to outperform industry standards and be a business differentiator.
Jeroen Boekema	Customer Support Manager	• Develop business cases – if we offer a product to the customer and part of it consists of parts being manufactured elsewhere, I would like to have upfront the best solution in terms of: ○ What is the cost price ○ Who are my best suppliers for this part ○ How am I going to get there ○ Total transportation costs ○ Can lead time be reduced ○ Which supplier is offering what • Purchasing and SC department should be working more actively together • SCM strategy should be to deliver the most optimal SC for our customer. Most optimal in terms of balanced QLTC aspects.

1.5.1.2 Research Framework

The research framework pictured in Figure 2 is based on the model of Sekaran (2003). It is a robust methodological research design which provides rigorousness and where the boxes represent process steps.

Once phase eight is reached and the problem statement is satisfactorily answered, report and presentation can be carried out. Otherwise, following the dotted grey arrows, revision of previous stages might be necessary. Blocks 1 and 2 – observation and preliminary data gathering – have been executed through the semi-structured interviews mentioned in the previous section (1.5.1.1), enabling the conclusion of block 3 – problem definition – which has been described and identified in section 1.4.

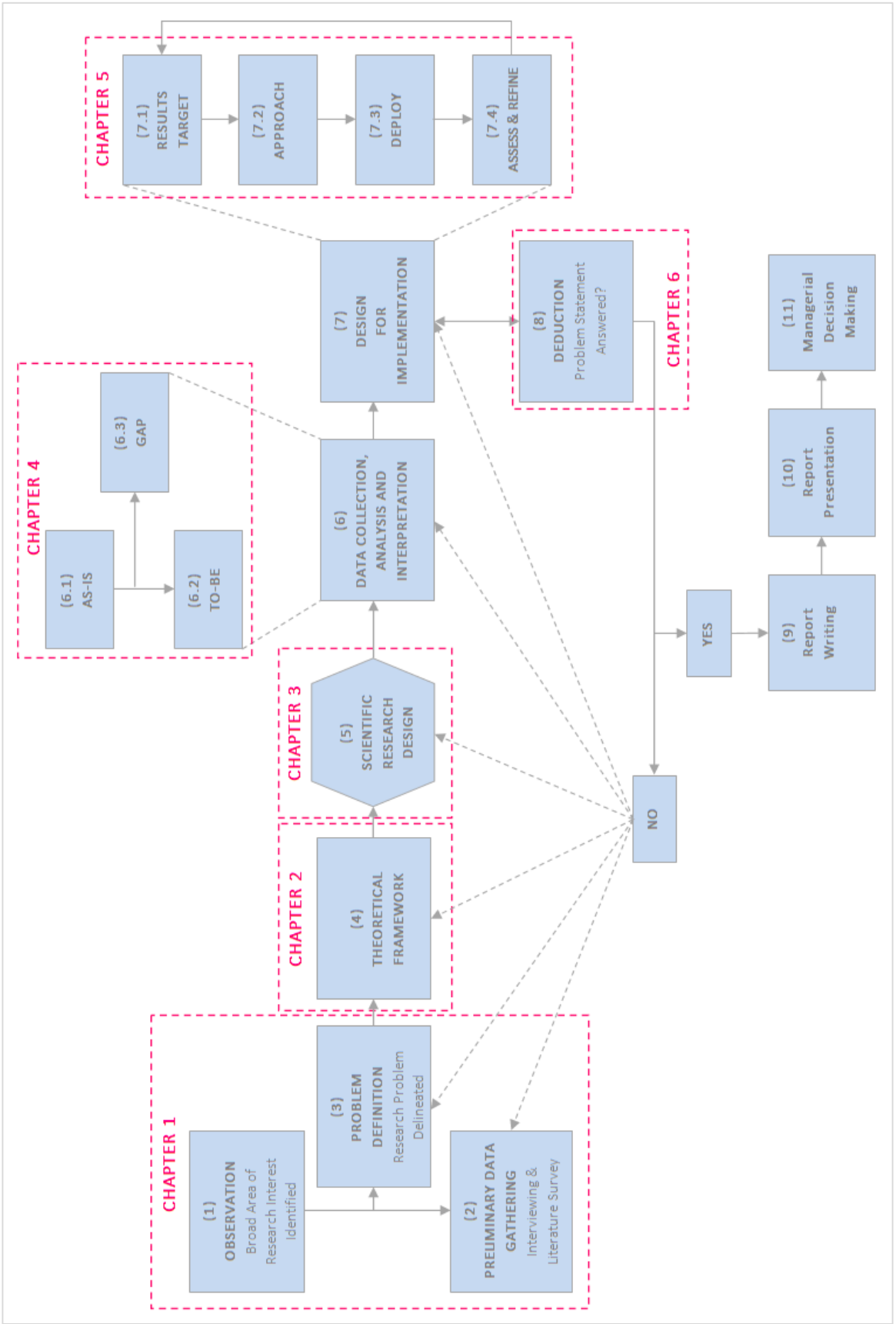

Figure 2: Research Framework, adapted from Sekaran (2003)

The step ‘Generation of Hypotheses’ is excluded from the original design because no suppositions are tested. Moreover, ‘Data Collection, Analysis and Interpretation’ being one of the core elements of the research, is further deepened with the division into the analysis of the AS-IS situation, the identification of the TO-BE position and the GAP(s) to be closed. Furthermore, the ‘Design for Implementation’ phase, representing the other key elements of the research, was added in order to complement Sekaran’s original method. It includes the RADAR logic, which was originally derived from the plan-do-check-act (PDCA) cycle popularized by Deming (1950) and currently used by the European Foundation for Quality Management (EFQM) on continuous cycle improvement. It is divided into the following four stages: Results Target, Approach, Deploy, and Assess & Refine.

1.5.1.3 Research Issue

To check the type of information that should be useful and/or necessary to achieve the research objectives, research questions were formulated and ought to be answered in the course of the study. Section 1.7 provides further data on the issues of this study and a summary of which topics need to be answered throughout the research.

1.5.1.4 Concepts Definition

Key concepts must be defined because they delineate the research one step further and looking at the empirical data simplifies the study itself. This is seen as the theoretical background, and is therefore described in Chapter 2.

1.5.2 Technical Research Design

Once the conceptual design has been fully acknowledged, the technical design takes place. It represents the second set of procedures and it refers to the decision-making process. To do so, initially, the type of *research material* that will be required to tackle the research issue must be entrenched. Next, the body of decisions is identified and this stage is called the *research strategy*. Finally, the *research plan* is determined.

1.5.2.1 Research Material

This section mentions how and where all the required material should be collected. In order to analyze relevant literature (secondary data) in the fields of SCM and PMSs at the high tech industry, a literature review was carried out. This gave way to the theoretical framework development. Around 140 scientific articles were analyzed and ScienceDirect, Google Scholar and B-ON were used to locate these papers. Most of them were retrieved from prestigious journals like: International Journal of Operations and Production Management, Journal of Operations Management, Management Accounting Research, International Journal of Production and Economics, Supply Chain Management: An International Journal, Accounting, Organizations and Society, Harvard Business Review, Journal of Business and Logistics, International Journal of Operations Management, and so on. The searched keywords were the ones indicated in the Abstract of this dissertation.

Time horizon was ideally the last 4 years, so from 2011-2015, nonetheless, this filter was not used in every search since some information was published before. This technique of data collection presents itself as reliable, since it is represented by worldwide professional journals, and straightforwardly collectable. Data regarding the case study (primary data) was collected through numerous meetings

and interviews with key stakeholders within VDL ETG, internal documents, company's enterprise resource planning (ERP) system and Business Intelligence Data gathering, etc. Primary data collection is described in more detail in Chapter 3.

1.5.2.2 Research Strategy

To the best of the author's knowledge, the scientific knowledge about SCPMMSs' design for implementation specifically for the high tech industry is much reduced and there is no information available on how this has been solved in the past. Under these circumstances, this type of research can be characterized as an exploratory research (Sekaran, 2003). Its purpose is not to develop new theory but somewhat offer awareness for further validation and development. For researches of this nature, a qualitative research strategy is the most suitable (Yin, 2002); especially in a practically oriented project (Verschuren and Doorewaard, 2004).

1.5.2.3 Research Planning

Finally, the research plan is made, emphasizing both practical and written output of the research.

1.6 Dissertation Objectives

Clear and specific aims for this dissertation are described next:

- Provide a clear introduction to this study (observations and preliminary data gathering which lead to the identification of the problem statement);
- Identify what is the optimal theoretical answer to the problem, matching it to current literature;
- Determine how to translate the optimal theoretical answer to the practical case, thus figuring out the solution for the problem statement;
- Clarify on how to collect the data;
- Data collection, analysis and interpretation as to what is the current situation of VDL ETG, where it should be and the corresponding gaps between the actual and desired state;
- Identify top priority gaps to close and suitable strategies to successfully do so;
- Develop the design for implementation: target for results are established, the approach for the design is made know, deployment of approach is executed and finally, assessments and reviews on conclusions are made;
- Lastly, identify if problem statement is answered.

1.7 Dissertation Research Questions

In order to accomplish the dissertation objectives and be one step closer towards answering the problem statement, the following research questions must be answered:

1. What is the theoretical background on the characteristics and design for implementation of internal SCPMMSs?
2. Which specific conceptual methods and approaches apply to SCP in the high tech manufacturing industry, and/or high mix & low volume, and why?
3. How can this effectively be applied to VDL ETG to drive customer value and lower total costs?
   (a) What SCPMeS and SCPMS do the stakeholders of VDL ETG currently apply (AS-IS)?
   (b) How should the chosen SCPMeS framework be effectively applied for VDL ETG (TO-BE)?

(c) *What is the final version of the chosen SCPMeS framework, taking into account all possible relations to business impact?*

4. What is the action plan that will enable the design for implementation of the SCPMMSs at VDL ETG?

(a) *What are the expected results from the design for implementation?*

(b) *What is the chosen approach for the successful design for implementation of the frameworks?*

(c) *How will the deployment proceed?*

(d) *What are the results from the design for implementation?*

This serves as a guideline during the research and gives an overview of what has to be clearly identified in order to advance to the next step and lastly accomplish all the objectives, thus making a step into the right direction for ultimately solving the problem statement.

1.8 Dissertation Outline

To conclude the first chapter of this research, the structure is now described. In Figure 2, the pink dotted boxes indicate the processes covered by each chapter. Since the problem has been defined, the theoretical framework is the next step on the plan, located in Chapter 2. This will serve as the basis for this research once it covers the current literature on SCM and PMMSs in a general environment and then it will be narrowed to the specific case of the high tech manufacturing industry, ending with the recognition of the chosen approaches. Scientific research design will be clarified in Chapter 3, it represents the *how* of data collection specifying which method was followed and appropriate conclusions to then execute data gathering effectively. Chapter 4 presents the case description and depicts the AS-IS SCPMMSs at VDL ETG. Moreover, it informs the desired TO-BE scenario for the company based upon the theoretical frameworks and information gathered with the body of respondents. The gaps between the present situation and the preferred one will also be acknowledged in this chapter, where the strategy to close them is presented and implemented. Chapter 5 explains the entire design for implementation process that is developed to ultimately solve and answer the problem statement. To conclude the research, Chapter 6 serves as a conclusion and recommendation section for the case company in order to achieve the desired TO-BE situation and future work to be established.

2 Theoretical Framework

2.1 Introduction

Literature *status quo* should be clearly explained in the earlier stages of a research to create awareness to the reader on the stakes of changing the argument (Boundless, 2014). This chapter identifies the theoretical framework used to deal with the empirical problem defined in the previous chapter as well as the chosen approach for the case study. It represents block 4 of the research framework (Figure 2) and addresses the first dissertation research question by presenting the state of the art of the main definitions, characteristics, and design and implementation approaches of an integral SCPMS. Subsequently, the second research question is discussed and the optimal theoretical frameworks are adjusted to the context of the research. This chapter should provide useful insight for the reader to: recognize the significance and context of the argument, and be convinced that this research will make an original contribution to the area being explored. A critical review will be conducted on the different methodological approaches performed by researchers on similar problems to justify the choice of methodology, data to be collected, instruments to be used, and so on. The following sub-questions are answered:

1. What is SCM and its goal and do SC strategies contribute to SCP?
2. What are the trends and critical success factors for SCM in the high tech & low volume industry and which SC strategy should be applied?
3. What is a PMS and what does it consist of?
4. Which design process to follow for acquiring an internal PMS and what is the optimal framework for SCM context?
5. What is a performance measurement system (PMeS) and what does it consist of?
6. Which design process to follow for acquiring an internal PMeS and what is the optimal framework for SCM context?
7. How to define key performance indicators (KPIs) and what are the theoretical SCM's KPIs?

2.2 Supply Chain Management

The term SCM was originally introduced by consultants, in the early 1980s (Oliver *et al.*, 1992) yet, there is no consensus as to the exact meaning of SCM since there are many definitions of SC and, consequently, SCM (Poiger, 2010). For the purpose of this study, the following definition by Mentzer *et al.* (2001) was chosen; it defines SCM as a "systematic, strategic coordination of the traditional business functions and the tactics across them, within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole". Within this definition, a SC is defined as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer."

This research will focus mainly on the study of the internal SC, which refers to the chain of activities within a company that concludes with providing a product to a customer (Basnet, 2013). Although many other attempts to define SCM have been made - by Chopra *et al.* (2009); Croom *et al.* (2000);

Villa (2001); Cooper *et al.* (1997) and Gibson *et al.* (2005) - they are not as all encompassing as this one (Giunipero *et al.*, 2008). Valmohammadi (2013), Giunipero *et al.* (2008) and Chen *et al.* (2004) mention that SCM has been a fusion of various fields, with influences from purchasing and supply, logistics and transportation, operations management, marketing, organizational theory, management information systems, and strategic management. The authors identify that this multidisciplinary characteristic is probably the cause for this plethora of definitions on the SCM concept. Nevertheless, significance and importance for both academics and practitioners is evident (Burgess *et al.*, 2006; Storey *et al.*, 2006 and Melnyk *et al.*, 2009).

The dynamics of faster product development set new expectation standards and traditional managerial attributes are being revised to improve firms' competitiveness in this new environment (Akdogan *et al.*, 2014). Organizations began to realize that delivering the best customer value at the lowest cost is not only related to the activities functions and processes within the organization itself, but to the whole of the SC (Barratt *et al.*, 2011). It is suggested in literature that traditional competition of company versus company is changing towards a business model where SCs compete against SCs (Prajogo *et al.*, 2012; Antai, 2011; Fawcett *et al.*, 1997; Li et al, 2006). This is because as much as a product or service itself is important to a firm, an effective SCM strategy can assist a company with an established and sustainable competitive advantage, if well executed (Martin, 2000).

2.2.1 SC Strategy & Performance

Competitive pressures are driving firms to continuously re-evaluate and adjust their SC strategies in order to improve performance, compete, and survive in the long-term. Manufacturers today are facing complex global challenges such as low cost competitors, fluctuating commodity prices, increasing customer expectations, and volatile economic conditions (Alomar *et al.*, 2014). To fill the void left by previous SCM research, a few attempts have been made to conceptualize SC strategy and formulate it in such a way that it can help firms increase their competitiveness in today's dynamic, uncertain, and risky business environment (Roh *et al.*, 2014).

Figure 3 clearly demonstrates that in order to make a SC strategy successful, the SC strategy should be closely aligned with corporate strategy as it shapes SC practices. SC practices with a solid SC strategy can enhance the firm's and its SC partners' business performance and thus their competitiveness (Fisher, 1997; Huang *et al.*, 2002). Furthermore, it is known that focused companies which practice a unique SC strategy have the following advantages over companies with dispersed ones: three to four times the return on capital employed, two to three times return on asset, two-thirds less time to increase output by 20% and one-third less variation in sourcing and production order cycles (Jacoby, 2010).

As the major issue of SCM is the proper design of its SCs (to successfully serve customers) (Poiger, 2010), dealing effectively with its uncertainties is one of the most crucial points in SC design (Birhanu *et al*., 2014). "Uncertainty in the functioning of any of the links may lead to delays and bottlenecking and may hamper the performance output of the SC," (Patil *et al.*, 2012). For this research, the focal point is on supply and demand uncertainties, since these are related to fulfilling demand and supply

for better customer service at the lowest possible cost. For one to overcome these uncertainties, different SC strategies emerge (Lee, 2002).

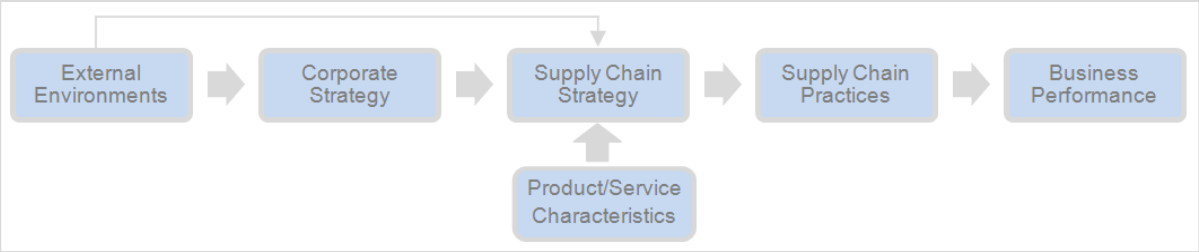

Figure 3: SC strategy and its role in business performance. Adapted from Fisher, 1997; Huang *et al.*, 2002.

2.2.1.1 Classification of SC Strategies

Classifications of SC strategies suggest that SCs can be predominantly focused on cost efficiencies and leanness, on flexibility and quick response, or on a contingent mix of both (Qrunfleh *et al.*, 2014). Classifications by Vonderembse *et al.* (2006) and Lee (2002) describe efficient (lean) SCs, risk-hedging SCs, responsive SCs, and agile SCs. Ozkir *et al.* (2011) extended the work of Agarwal *et al.* (2006), Vonderembse *et al.* (2006) and Lee (2002), and identified an additional SC strategy, le-agile SCs, which is a mixture of lean SCs with agile SCs. Table 3 identifies the characteristics of these five different types of SC strategies which can be recognized in a business organization and compares them based on performance attributes and characteristics (adopted from Ozkir *et al.* 2011). Furthermore, it also indicates the optimal theoretical solution as to; what the purchasing policy should be and how this strategy will affect attributes of quality, cost, lead time and service level.

2.2.1.2 Optimal Strategy for Research Context

To conclude which SC strategy would be the optimal theoretical solution for the context of this research, one has to analyze each attribute and decide what the best fit is. Within the high tech (semiconductor) industry, where product types are highly innovative, supply uncertainty can both be high or low (depending on the specific product), market demand is volatile and unpredictable (following the demand pattern of the silicon market), and lastly, the major customer driver is service level, from Table 3 it is clear that the best SC strategy is le-agile. Under these circumstances, a conclusion is brought up to identify that the purchasing policy for this strategy, and therefore for the company case study, is vendor managed inventory (VMI). Additionally, the performance attributes (PAs) which stand out bringing the uniqueness of le-agile SCs are cost and service level. In theory, when adopting this strategy, an enterprise becomes a market winner in those two PAs.

Lastly, it is acknowledged that SCM has become a key strategic factor for organization success (Cai *et al.*, 2009; Fine, 1998) and the era of both globalization of markets and outsourcing has begun (Sum *et al.*, 2001; Tan *et al.*, 2002). Accordingly, in order to evolve to an efficient and effective SC for business competitiveness improvement, most companies realize that SCM needs to be recognized as a strategic asset and requires performance assessment (Gunasekaran *et al.*, 2008; Sum *et al.*, 2001; Tan *et al.*, 2002).

Review of literature indicates the existence of a positive and significant relationship between SCM and performance, supported by the following studies: Akdogan *et al.* (2014), Chong *et al.* (2011); Petrovic-

Lazarevic *et al.* (2007); Li *et al.* (2006); Koh *et al.* (2007); Miguel *et al.* (2011); Spens *et al.* (2009). Next section will focus on the performance aspect of business and the different frameworks to measure and manage it.

Table 3: Types of SC Strategies. Source: Adapted from Lee (2002); Vonderembse et al. (2006); Birhanu et al. (2012); Roh et al. (2014); Fisher, (1997).

Attributes & Characteristics	Efficient (Lean) SC	Risk-Hedging SC	Responsive SC	Agile SC	Le-agile SC
Supply Uncertainty	Low	High	Low	High	High or Low
Market Demand	Predictable	Volatile	Predictable	Volatile	Volatile & Unpredictable
Definition	Mature market. Low cost and high productivity to achieve competitive advantage. Continuous improvement efforts which focus on eliminating waste or non-value steps along the chain, thus, improving the quality of parts, reducing delivery times and minimizing inventory.	Used when supply chain is filled with risk and uncertainty. To leverage supply uncertainties, a firm would increase buffer stocks for its core products and attempt to share the cost of the safety stock with its supply chain partners.	Suitable for firms that offer a variety of innovative or customized products tailored to specific customer demands and taste. To accommodate customers' fluctuating demands, this strategy may postpone the final assembly/manufacture of a product until the demand becomes know.	Increasing flexibility and enabling velocity to adjust promptly to volatile market conditions and to unpredictable sources of supply. Responds to rapidly changing, continually fragmenting global markets by being dynamic, context-specific, growth-oriented and customer focused.	Combines capabilities of lean and agile SCs to create a supply network that meets the needs of complex products.
Customer Drivers	Cost and quality.	Lead time, quality, cost-efficiency and hedging the risk of supplier disruptions.	Quality, flexibility and availability (adapting to rapidly changing customer needs).	Lead time and availability.	Service level
Product Type	Functional	Functional	Innovative	Innovative	Functional or Innovative
Purchasing Policy	Buy Goods	VMI	Assign Capacity	Assign Capacity	VMI
Quality	MQ	MQ	MQ	MQ	MQ
Cost	MW	MW	MQ	MQ	MW
Lead Time	MQ	MQ	MQ	MQ	MQ
Service Level	MQ	MW	MW	MW	MW

Label: VMI= Vendor Managed Inventory; MQ= Market Qualifier; MW= Market Winner

2.3 Performance Management System

PMS are widely used and yet, when further explored, they provide considerable variety of meaning (Broadbent *et al.*, 2009). For example, PMS is often used in the context of human resources management systems and in relation to controlling individual employee behavior, but it may also refer to management, management control and accounting (Broadbent *et al.*, 2009). Radnor *et al.* (2007) defined PMa as actions, based on PMe and reporting, resulting in overall improvements. According to the United States Office of Personnel Management, "… PMa includes:

- Planning work and setting expectations;
- Continually monitoring performance;

- Developing the capacity to perform;
- Periodically rating performance in a summary fashion;
- Rewarding good performance."

2.3.1 Conceptual Performance Management System Frameworks

Variety on different perspectives and frameworks concerning dimensions for managing performance is limited, especially when narrowing PMSs to the SC point-of-view. Whilst reviewing literature, three PMa frameworks were established, one generic and two specific to SC environment. The frameworks are described next.

2.3.1.1 PMS Framework 1

Ferreira *et al.* (2009) developed a PMS framework which represents an upgrade from Otley's previous 5 'what' questions to 10 'what' and 2 'how' questions (Otley, 1999). It is a general PMS and its aim is to give a managerial emphasis, by integrating various dimensions of executive activity with the control system. Contextual factors and organizational culture are two aspects that pervade the PMS but are not explicitly addressed by the 12 questions (Ferreira *et al.*, 2009).

Literature has shown that variables relating to external environment, strategy, culture, organizational structure, size, technology, and ownership structure have an impact on control systems design and use (e.g. Chow *et al.*, 1999; Firth, 1996, Gordon *et al.*, 1984; Khandwalla, 1972, 1974; O'Connor *et al.*, 2004; Perrow, 1967; Simons, 1987). Hence the importance of considering these two aspects when studying the operation of the PMS. Taking into consideration the context of this research, Table 4 provides an overview of the advantages and disadvantages of this framework, elaborated by the author.

Table 4: Advantages and disadvantages of PMS Framework 1

Advantages	Disadvantages
• Very descriptive, easy to follow • Identification of key success factors are present • Information sharing is emphasized • Contextual factors and culture are taken into account	• General framework, broad perspective • No KIP feedback loop for constant analysis

2.3.1.2 PMS Framework 2

Mutingi *et al.* (2014) provides a framework for the development of PMSs specifically to SC context. It consists of five phases: 1- developing a performance management function, 2- diagnosis and analysis, 3- developing an action plan, 4- developing a performance measurement system, and 5- developing a PMS. Once again, in Table 5 the reader can find an overview made by the researcher, establishing the advantages and disadvantages of this framework when applied to the context of the case study.

Table 5: Advantages and disadvantages of PMS Framework 2

Advantages	Disadvantages
• Specific for SC • Very descriptive • Easy steps to follow and keep track of progress	• No emphasis on information sharing • No reward system • No KPI feedback loop • No key success factors are taken into account

2.3.1.3 PMS Framework 3

Cai *et al.* (2007) developed what is called in this research PMS framework 3. It is also a specific framework for SC context. The authors state that traditional supply chain performance management (SCPM) has always been approached as a top-down process that conforms the six steps of the management cycle. 'KPI Accomplishment' is referred as the mechanism to achieve KPI goals (which connects planning and execution, and builds steps for realization of performance goals into a regular perspective) (Cai *et al.*, 2009).

As it was already mentioned in previous sections, the complex PMS include several management processes. It is essential to make these processes embedded in information systems solutions for the correct measure and monitor of KPIs which are crucial for optimizing the SCP (Cai *et al.*, 2009). To overcome the issue of shorter Performance Management Cycle (PMC), Cai *et al.* (2009) proposed to add a new step, i.e. analyze KPI, into the management cycle, and build a quicker feedback loop.

After the first step, which defines and articulates SC KPIs, and the second step, which identifies operational factors and builds management models, the new step is executed. It analyzes the intricate relationship among KPIs and simulates their accomplishment (connecting planning and execution, and building steps for realization of performance goals into routine daily work). Table 6 presents the overview of advantages and disadvantages of this framework, resulting from the researcher's analysis.

Table 6: Advantages and disadvantages of PMS Framework 3

Advantages	Disadvantages
• Specific for SC • Information sharing is emphasized • KPI feedback loop present	• Too simple • Not descriptive • No reward system • No key success factors are taken into account

2.3.2 Chosen PMS Framework

After a detailed description and analysis of the three PMS frameworks pointed out by literature, and before describing the focus points of each framework, it is important to state what they have in common. All frameworks underline the significance of a top-down approach, where the first step is identifying the vision and mission of a company in order to set goals. Additionally, all frameworks follow to some extent the structure of the PDCA cycle; briefly explained in the research framework, section 1.5.1.2. This makes sense since the structure is popular when one wants to control and continuously improve processes and products.

On the other hand, the frameworks have their own unique elements and to make this clear, Table 7 offers a clear summary and comparison of all frameworks in terms of the key characteristics acknowledged from their advantages/disadvantages. Framework 1 is presented as a general PMS outline whereas frameworks 2 and 3 are specific for a SC context. For this reason, frameworks 2 and 3 take advantage in comparison to framework 1 because when adopting such a structure, one must always take into account the context in which the framework will be applied or studied. Thus, opting for a PMS that is specific to the SC context over one that is very generalist is ideal. The descriptive characteristic refers to the extent to which the end user of the PMS framework can follow the structure and content of the several steps of the system.

Table 7: Comparison of all PMS Frameworks

Characteristics	Framework 1	Framework 2	Framework 3
Specific		x	x
Descriptive	x	x	
Information Sharing	x		x
KPI Feedback Loop			x
Key Success Factors	x		

Since researchers suggest that closer information-based relationships become an enabler of effectively managing SCs which seek improved performance through effective use of resources and capabilities (Ding *et al.*, 2011), this characteristic was taken into account when comparing all the PMS frameworks. Framework 2 lacked this feature meanwhile the other two made a considerable highlight for information sharing. One of the strongest points for framework 3 is the existence of a KPI feedback loop, which the other frameworks fall short of.

Last but not least, the contemplation of key success factors provide extra strength for framework 1 since it is an essential aspect for awareness creation in enterprises at the initial stage of designing a PMS framework that should enable improved performance of their SC.

To sum up, and in view of all these observations, the conclusion drawn is that there is no framework that is perfectly adjustable to the context of this research. The semiconductor industry, and more specifically, VDL ETG, with its distinctive practices of high mix and low volume, should consider all the characteristics from the above Table 7 when developing a PMS framework for superior SCP in order to gain competitive advantage, by outperforming the market. The complexity of this market makes it compulsory to have a PMS that incorporates all the aspects mentioned, and with this in mind, this research will not follow one of the frameworks identified by review of literature. Henceforth, a new framework was established, including all the important attributes stated, and therefore resulting in a mixture of frameworks 1, 2 and 3. The chosen framework is described below.

Figure 4 schematizes the proposed SCPMS framework for driving overall performance of VDL ETG's SC. It is composed of all the strongest points and characteristics of the three frameworks analyzed above. By this, it should provide the best theoretical design of a SCPMS and the several steps for implementation.

Step 1: Supply Chain Performance Management Function

By identifying the SC's vision and mission for VDL ETG, the main goals of SC and SCM are derived. Once these goals are well-known, a certain performance for those goals can be set up. It is crucial to create awareness of these objectives to all stakeholders that are in some way linked and involved - directly and indirectly - in this process. Then, the key success factors should be established in order for them to serve as an enabler of future SC success.

Step 2: Diagnosis and Analysis

Diagnose the AS-IS (current) situation and then the desired TO-BE scenario, followed by the identification of the existing gaps between both states of affairs. Lastly, the gaps that will be addressed must be pointed out, to clearly state what the company wants to improve.

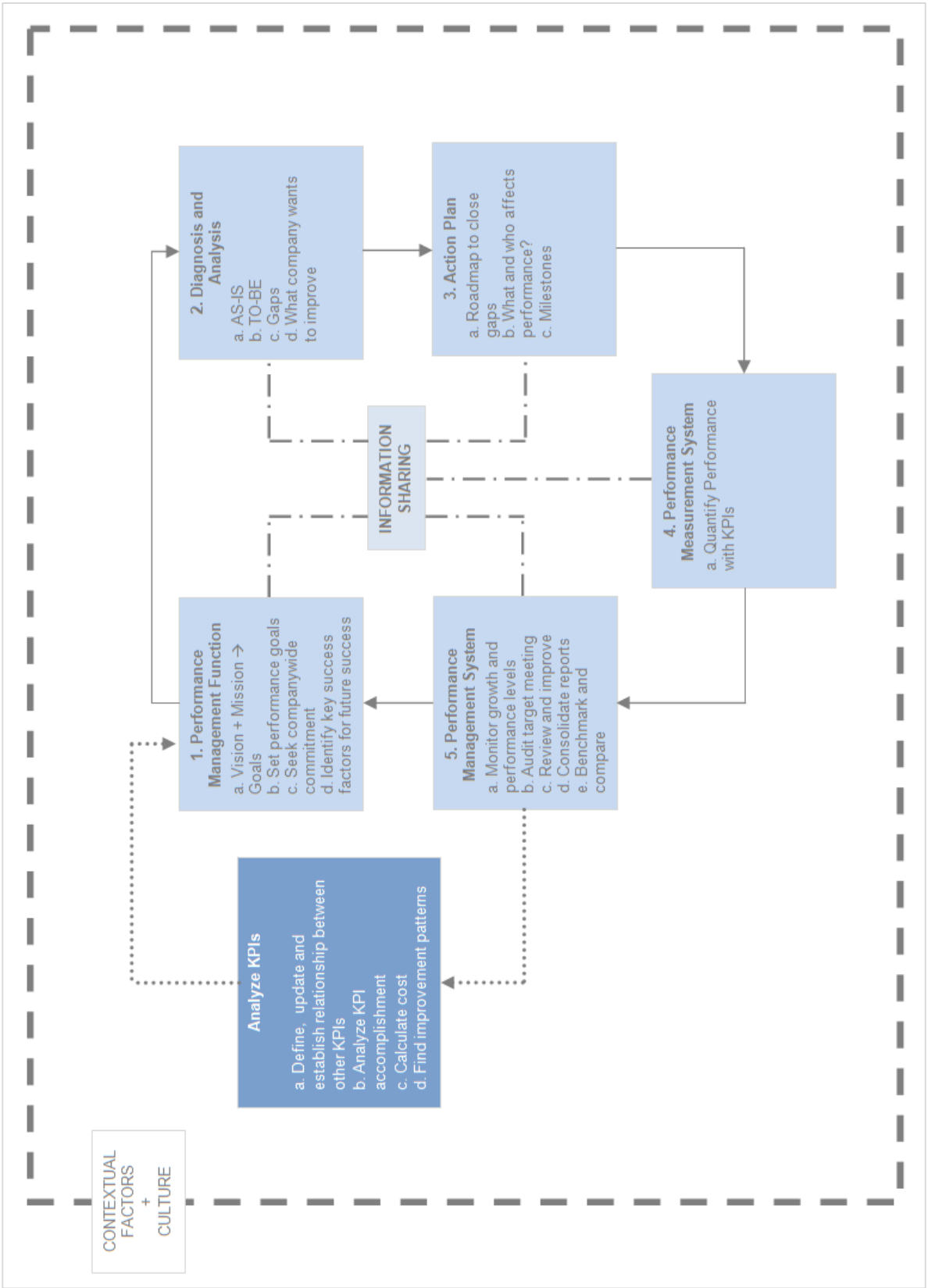

Figure 4: Proposed SCPMS Framework

Step 3: Action Plan

Specific solutions to help meet the performance goals and close the gaps should be made into a roadmap; moreover, identification of 'what' and 'who' is affecting performance is a must. Milestones have to be developed to track progress.

Step 4: Supply Chain Performance Measurement System (SCPMeS)

A SCPMeS is established in this phase, with the purpose of being able to quantify the SCP. To do this, SC KPIs must be identified.

Step 5: Supply Chain Performance Management System

Monitoring growth and performance levels are executed by this step. Audits should be done to assess whether the improving targets are being done. Correct resource allocation is carried out, based on the review and improvement of growth, to improve SCP. Report consolidation comes next and to finalize this step, VDL ETG should execute benchmarking activities to compare their performance with fellow companies.

Analyze KPIs

This step represents the key performance indicator (KPI) feedback loop present in framework 3 and it is taken into account for this PMS framework because of the dynamic characteristic present in the SC context. It is placed between the last step and returns to the initial one, since updates are made and new goals are derived. Here one must define and establish the relationships between the existing KPIs, studying how one KPI affects another, as well as updating them. Analyze KPI accomplishment comes subsequently, followed by cost calculation, covering all costs involved in the accomplishment. Lastly, improvement patterns may be identified.

Information Sharing

Through the establishment of both internal and external connections aligned compatibly with system-wide objectives (Yu *et al.*, 2010), organizations shift from arm's length to an integrated range of possible relationships (Barlow *et al.*, 2005), thus creating a flawlessly coordinated SC that is a potential source of competitive advantage (Barratt *et al.*, 2011). In view of this, including information sharing on the chosen PMS framework is seen as vital, hence it was included.

Contextual Factors & Culture

Framework 1 strongly emphasizes the inclusion of the contextual factors and culture of the company at stake. Organizational culture, a notable contextual variable, pervades the entire control system influencing choices and behaviors of individuals (Cai *et al.*, 2009; Hofstede, 1984; Tompenaars *et al.*, 1997). So the study and understanding of the operation of the control system benefits from the consideration of the impact of culture (Cai *et al.*, 2009). This presents enough reason for the inclusion of these aspects, taking them into account on every step of the SCPMS framework.

Table 8 provides a summary of which framework, pointed out by literature, inspired what step of the chosen framework, and the frequency of executing each step. The mixture of the best features of each PMS framework should, theoretically speaking, provide the case company with a system that encompasses the process (or processes) of assessing the differences between actual and desired

outcomes, identifying and flagging those differences that are critical (thereby warranting management intervention), understanding if and why the deficiencies have taken place, and, when necessary, introducing (and monitoring) corrective actions aimed at closing the significant performance gaps (Melnyk *et al.,* 2013).

Table 8: Chosen framework inspiration source

Chosen Framework Steps	Inspired by	Frequency of Execution
1: SCPM Function	• Question 2 from Framework 1 • Step 1 from Framework 2	Yearly
2: Diagnosis and Analysis	• Step 2 from Framework 2	Quarterly
3: Action Plan	• Question 4 from Framework 1 • Step 3 from Framework 2	Quarterly
4: SCPMeS	• Question 5 from Framework 1 • Step 4 from Framework 2 • Model Phase of Framework 3	Quarterly
5: SCPMS	• Question 6 and 7 of Framework 1 • Step 5 of Framework 2 • Plan, Monitor, Analyze and Report Phases of Framework 3	Quarterly
Analyze KPIs	• Analyze KPIs Phase of Framework 3	Yearly
Information Sharing	• Question 9 from Framework 1 • Shared Information Characteristic of Framework 3	Daily
Contextual Factors & Culture	• Framework 1	Daily

SCPM Function and *Analyze KPIs* both have a yearly execution frequency since these steps are characterized by setting companywide and SC goals and targets and updating KPIs. These types of activities do not suffer change that often, hence why its execution is done on a yearly basis. Whereas *Diagnosis and Analysis, Action Plan,* SCP*MeS,* and SCP*MS* have a greater incidence given that they are directly aligned with everyday activities. Frequency of execution is then advised by the researcher to be on a quarterly basis. For obvious reasons, *Information Sharing* and *Contextual Factors & Culture* are executed every day since they represent the basis for any decision and action.

Moreover, this SCPMS framework meets international standards for ISO 13485 (medical devices), ISO 9100 (aerospace industry) and ISO 9001, which is an essential requirement for the context of the case study. VDL ETG operates with those three ISO certificates so when developing a system to be implemented at the company, one needs to make sure that this system meets all prerequisites demanded from these standards.

Next section will focus on step 4 – SCPMeS - of the chosen PMS framework and the reason for this is that, as explained in the problem motivation, if one cannot measure, one cannot control it; if one cannot control it, one cannot manage it; and if one cannot manage it, one cannot improve it (Rao, 2011).

2.4 Performance Measurement System

PMe is often defined as the process of quantifying action (Feigenbaum, 1986; Neely *et al.*, 1995), where measurement is the process of quantification and actions lead to performance. Lohman *et al.* (2004) states that PMe has several objectives like creating focus, it represents the basis for evaluating performance, triggers corrective actions, and may help challenging and improving strategic choices.

Hence, selection of metrics and targets are therefore seen as concrete formulations of the firm's strategic decisions (Lohman *et al.*, 2004).

PMeS executes PMe in a consistent and complete way where it is a balanced and dynamic system (software, databases, procedures) enabling decision-making by gathering, elaborating and analyzing information (Neely *et al.*, 2002). This definition was established after intense review of work done by Kaplan *et al.* (1992; 1996) and Bititci *et al.* (2000), where 'balance' refers to using different perspectives that collectively provide a holistic view (Kaplan *et al.*, 1996). 'Dynamic' refers to continuously monitoring developments in the internal and external environment, reviewing objectives and deploying these in critical parts of the organization (Bititci *et al.*, 2000).

The measures capture the essence of organizational performance and are the foundation of measuring performance (Gunasekaran *et al.*, 2004). The definition of these targets should undergo gradual changes (Gutierrez *et al.*, 2014). Next, the most widely used conceptual PMeS frameworks are identified and explained.

2.4.1 Conceptual Performance Measurement System Frameworks

Going back to the SCM definition established by Mentzer *et al.* (2001), Kurien *et al.* (2011) classified SCP measures as follows:

- Fund flow (cost and profitability);
- Internal process flow (production level flexibility, order fulfillment and quality);
- Material flow (inventory and internal time performance);
- Sales and services flow (delivery performance, customer responsiveness and customer satisfaction);
- Information flow and partner relationship process flow (supplier evaluation and sharing of information with suppliers and customers).

A number of PMeS frameworks have been developed since the 1980s (Bititci *et al.*, 2000). These frameworks have their own relative benefits and limitations. Literature review indicates that empirical and theoretical validity of some of the frameworks are established whereas information about others is not available. This research does not examine all the PMeS that were found in literature since the variety is high, so next section is an attempt to study three of the most cited and used PMe frameworks.

2.4.1.1 PMeS Framework 1 – Supply Chain Operations Reference Model (SCOR)

Supply Chain Council's SCOR Process Reference Model comprises; standard descriptions of management processes, a framework of relationships among the standard processes, standard metrics to measure process performance, management practices that produce best-in-class performance, and standard alignment to features and functionality.

SCOR links company strategy to business operations. Measurements must link to business objectives, provide insights into how to manage the SC more effectively and must be appropriate for the process activity they are measuring (belong to the same level).

All process metrics are an aspect of a performance attribute. The performance attributes for any given process are characterized as either customer-facing (reliability, responsiveness and flexibility) or internal-facing (cost and assets) metrics. These top level metrics are the calculations by which an implementing organization can measure how successful they are in achieving their desired positioning within the competitive market space. Lower level calculations (level 2 metrics) are generally associated with a narrower subset of processes. Additionally, even lower level metrics (diagnostics) are used to diagnose variations in performance against plan. For example, an organization may wish to examine the correlation between the request date and commit date (Stefanovic *et al.*, 2011).

2.4.1.2 PMeS Framework 2 – Balanced Score Card (BSC)

The BSC concept is used for measuring whether the company is meeting its objectives in terms of its vision and strategy (Bhagwat *et al.*, 2007; Kaplan *et al.*, 1992). This model can be seen as a PMeS, a strategic management system, a change management tool and/or a communication tool. Depends on how an individual firm wants to use it as a single comprehensive system/tool or along with other existing systems/tools. This is done using four perspectives; financial, customer, internal business processes, and learning and growth. PIs are suggested for each perspective as follows:

- Financial – Return on Investment (ROI), cash flow, financial result, return on capital employed and return on equity;
- Customer – Delivery performance by date and quantity, customer satisfaction and customer retention;
- Internal Processes – Number of activities, opportunity success rate, accident ratios and defect rates;
- Learning and Growth – Investment rate, illness rate, internal promotion percentage, employee turnover and gender/racial ratios.

Since these above measures can be many and will vary from firm to firm, the key is to strike a ‘balance’ amongst all of them to truly reflect and measure what are the particular firm’s key success factors or KPIs (Bhagwat *et al.*, 2007; Kaplan *et al.*, 1992).

Thus, a BSC is all or any of the following; PMeS, a strategic management system, a change management tool and a communication tool. It depends on how an individual firm wants to use it as a single comprehensive system/tool or along with other existing systems/tools.

2.4.1.3 PMeS Framework 3 – Strategic Measurement Analysis and Reporting Technique (SMART)

There are several frameworks which encourage executives to pay attention to the horizontal flows of materials and information within the organization, i.e. the business processes. Lynch and Cross’s Performance Pyramid (SMART) ties together the hierarchical view of business performance measurement with the business process view (Ghalayini *et al.*, 1996).

It also makes explicit the difference between measures that are of interest to external parties – customer satisfaction, quality and delivery, and measures that are primarily of interest within the business – productivity, cycle time and waste (Neely *et al.*, 2000).

Corporate vision defines the markets in which and the basis on which the company will compete. A company's vision and strategy directly translate into how the company plans to reach its goals and what measures are truly critical to the plan's success. In the strategic level point of view, for the company as a whole to reach its vision, each of the business units (BUs) must play its part. Most BUs define success in terms of (1) achieving the long-term goals of growth and market position and (2) achieving the short-term goals of specified levels of positive cash flow and profitability (Lynch *et al.*, 1995).

On a tactical level, the core processes are the bridge between the top-level, traditional indicators and the new day-to-day operational measures in the new paradigm. They include all internal functions, activities, policies and procedures, and supporting systems required to implement a particular business strategy, involving the development, production, and provision of specific products or services to particular markets. Recognition of core processes provides all employees with a unified purpose, a shared sense of a larger mission, a sense of urgency, and the flexibility to focus on what counts the most. Meanwhile, in the operational level, any effective control system must be based on a tightly defined linkage between measurements at the local operational level and the objectives and priorities of the core process. The elements of this linkage are found in four principal local operating performance criteria: quality, delivery, cycle time, and waste. Any objective of any function or department in the core process is to increase quality and delivery and to decrease cycle time and waste.

2.4.2 Chosen PMeS Framework

Literature mentions there are six requirements which need to be addressed when developing a PMeS. These requirements are: the existence of financial and non-financial metrics, internal metrics related to anything having to do with in-house activities but also external metrics related to customers and suppliers, metrics that represent the present performance but also ones that focus on future goals, strategy must be aligned with the framework since all targets are derived by it , vertical integration is a must as it merges all hierarchical levels from strategy to operations, and last, horizontal integration is required so all departments are integrated to seek company goals. Table 9 provides further descriptions about each requirement and its sources. With these requirements, one can assess the quality of the three frameworks mentioned above and choose the best model (theoretically). Results are shown in Table 10. The framework containing all or most of the requirements is indicated as the best suit.

From Table 10 it is derived that the SMART pyramid supports all requirements as so for this reason, framework three is seen as the strongest framework and is chosen. It is a simple and concrete approach that everybody understands. SCOR model could have been the chosen since it is specifically for the SCM context but it presents itself as highly complex and its scope is on a very operational level. SMART's strength is in vertical integration between strategic, tactical and operational level as well as horizontally within these levels. (E.g. flexibility affects customer satisfaction positively but productivity negatively and is therefore in between).

Table 9: Requirements needed to be addressed in any PMeS framework

	Requirements					
Aspect	**Financial and non-financial metrics**	**Internal and external performance**	**Present and future oriented performance**	**Strategy Alignment**	**Vertical Integration**	**Horizontal Integration**
Further Description		Both the input (i.e. supplier performance) as well as the output (i.e. customer experience) side of the organization.	What has been achieved long-term oriented measures, used to help predict future performance should de covered by the framework.	Performance metrics should be directly related to the company's strategy and objectives.	KPIs should be hierarchically drillable into detailed PIs so that operations are linked to strategic goals.	KPIs should be integrated across the different functions in an organization.
Authors	Blenkinsop *et al.* (1991); Eccles, (1991); Maskell, (1991); Kaplan *et al.* (1992); Neely *et al.* (1996); Bourne *et al.* (2003); Schultz, (2006); Eckerson, (2009).	Fortuin, (1988); Lynch *et al.* (1995); Kaplan *et al.* (1992); Neely *et al.* (1996); Bourne *et al.* (2003).	Blenkinsop *et al.* (1991); Lebas, (1995); Neely *et al.* (1996b); Bourne *et al.* (2003).	Globerson, (1985); Dixon *et al.* (1990); Lynch *et al.* (1995); Maskell, (1991).	Neely *et al.* (1996b); Eckerson, (2009); Lynch *et al.* (1995); Wisner *et al.* (1991).	Flapper *et al.* (1996); Neely *et al.* (1996b); Bititci *et al.* (2012).

Table 10: Comparison of the six PMeS frameworks in terms of requirements from literature

PMeS Framework			Financial and Non-Financial	Internal and External	Present and Future	Strategy Alignment	Vertical Integration	Horizontal Integration
No.	**Name**	**Perspective**						
1	SCOR	Strategic Management	x	x		x	x	x
2	BSC	Strategic Management	x	x	x	x		x
3	SMART	Strategic Management	x	x	x	x	x	x

Figure 5 represents the adapted SCPMeS framework, based on SMART pyramid. Since the context of the research is SCM, some modifications were made to the original pyramid. *Vision* becomes the *SC vision*, where the strategic course of the company's SC is set.

At the second level, objectives are defined in financial and non-financial terms: *total cost of ownership* and *customer value*, instead of *market* and *finance* respectively. This is because the ultimate goal of this research is to provide an integral SCPMS whilst maximizing customer value at the lowest total cost, based on the SC strategy in focus for VDL ETG. *Customer value* represents long term goals for value generation levels and identifying what customers are willing to pay for the products VDL ETG

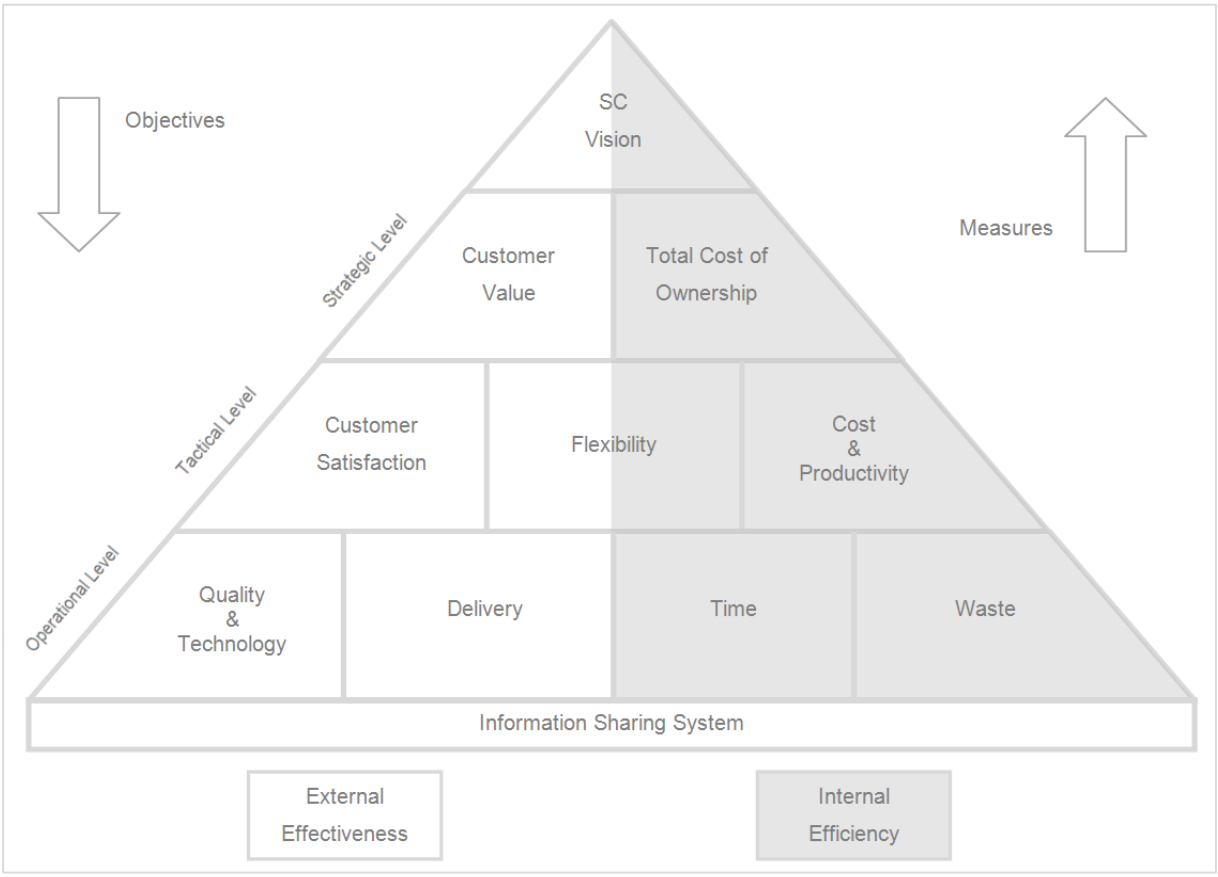

Figure 5: Adapted SCPMeS framework

supplies. On the other hand, *total cost of ownership* refers to the long term financial goals and how internal results impact this aspect.

Moreover, successful companies compete on three fronts: customer satisfaction, flexibility and productivity (Lynch *et al.*, 1995). On this tactical level, instead of just considering the aspect of *productivity*, *cost* was added on top of. *Customer satisfaction* is assessing the management of customer expectations, *flexibility* evaluates the responsiveness of the process/system to change, and *cost and productivity* appraises if resources are effectively managed, focusing on costs. Since it has increasingly become a major concern for the case company, giving a bigger emphasize on *cost* is a requirement and there are more types of costs that must be taken into consideration that are not related to *productivity. Flexibility* affects *cost and productivity* negatively whilst in terms of *customer satisfaction* the effect is positive, so it is strategically positioned in between these aspects.

Finally, on the operational level, not much changed. Since the context of this research is the high tech industry, *technology* is vital and mostly associate it with *quality*, hence the merging of these two aspects into the block that was originally just *quality*. The primary goal is to meet customer expectations through delivery of defect-free products and/or services meeting all the technological requirements. The last modification is related to the block *cycle time*. To include this original aspect would be to limit the scope of *time* and not take into account the various other forms of it. Hence, the aspect was broadened to *time,* where cycle time is an example of a KPI. *Delivery* assesses whether

VDL ETG delivered what the customer requested. *Waste* is all the non-added-value activities and resources needed for meeting customer requests.

Since this framework is integrated within the chosen PMS framework, at the base of the pyramid lays the *Information Sharing System* where information accuracy, availability, timeliness and sharing are reviewed. Without an effective and efficient information system, data cannot be collected, analyzed and interpreted so it presents itself as a condition for performance improvement.

The strength of this framework is the integration level of services as an added value for the customer (Lynch *et al.*, 1995). *SC vision* will determine the ultimate goal, where *customer value* and *total cost of ownership* are the strategies applied for meeting this goal. Through *customer satisfaction, flexibility* and *cost & productivity*, these strategies can be met. On an operational point-of-view, *Quality & technology, delivery, time* and *waste* are the enablers of these tactical aspects.

Ideally, one or two KPIs are determined for each block, and a set of three PIs are identified. This makes it possible to measure the SCP on the several categories, and once measured, spot the weaknesses and set improvement targets. One must always take into account the direct and indirect links between all the KPIs within the framework.

Some KPIs can be derived from theory but these only serve as a guideline to the actual KPIs, and in order to have the most accurate model, company's stakeholders must be the ones to derive the KPIs for each category.

2.5 Developing Performance Measures

In SC, large volumes of raw transactional data are generated by each process and stored, and followed by this, the challenge many companies face lies in determining what information is necessary to drive improvements and efficiencies at each process in the SC, and designing an information management environment to turn the raw data into meaningful metrics and KPIs (Stefanovic *et al.*, 2011). KPIs are measurements that directly relate to key business requirements to very complex, cross correlated analytic results (Stefanovic *et al.*, 2011). Moreover, they are the most important PIs which directly reflect strategic objectives.

The level of aggregation of measures is an important aspect highlighted in literature (Globerson, 1985; Lohman *et al.*, 2004; Braz *et al.*, 2011). Thus, managers should seek a good balance of measures providing a holistic view of organizational performance (Gutierrez *et al.*, 2014).

KPIs are often clustered in certain categories and a collection of detailed PIs can be used to provide substance to each KPI (Neely *et al.*, 1995: Slack *et al.*, 2007: Eckerson, 2009). Since many measurement systems are static (i.e. not dynamic), they often lag behind the constantly varying contexts in SCs (Cai *et al.*, 2009). Once the measurement systems have been established, they are rooted, and remain unchanged, for a long time (Cai *et al.*, 2009). But in the dynamic SC environment, some measures actually get outdated and yet remain entrenched, especially the preset KPIs (Cai *et al.*, 2009).

Second, few measurement systems have a systematic methods for prioritizing the measures (Neely, 2005) and, therefore, many companies have difficulties in figuring out ways of adapting their continuously changing strategic objectives and meeting the requirements of the dynamic decision-

making environment (Cai *et al.*, 2009). It is critical for performance measurement systems and related criteria to be updated and evaluated constantly (Beamon, 1999; Shepherd *et al.*, 2006).

2.6 SCM KPIs

SC metrics are needed to sustain competitiveness and to differentiate product and service offerings (Lambert *et al.*, 2002). Management is forced, by the commoditization of products, to examine the SC for determining opportunities to increase revenues and eliminate costs (Keebler *et al.*, 1999). Integrated metrics will allow management to assess the competitiveness of the SC as a whole and to determine which internal improvement efforts will produce the greatest impact on overall competitiveness (van Hoek, 1998).

Improving SCP is a continuous process that requires both an analytical performance measurement system, and a mechanism to initiate steps for realizing KPI goals (Cai *et al.*, 2009; Gunasekaran *et al.*, 2004). KPIs are derived from SCM practices and capture the impact of the actual working of SCs on a number of factors of the whole system.

In measurement system design, the challenge lies in choosing the right measures; it is identifying what needs to be measured so as to concentrate on what is absolutely vital. Based on the chosen theoretical PMeS framework, several SC KPIs were derived from literature review, shown in Table 11 and organized against the adapted SMART pyramid herein proposed.

These metrics are aggregated buy the researcher and classified at the three different levels – strategic, tactical, and operational – to clarify the appropriate degree of management authority and responsibility for performance. Moreover, metrics are divided into each block of the SMART pyramid to provide a clear vision of PIs for each attribute.

Table 11 also mentions which authors proposed which KPIs, where definitions for these are not made clear. As this is derived from theory, and acknowledging that KPIs are specific for each company (and even each customer since they have specific requirements), this table serves as a guide for managers to have when coming up with the specific, context wise KPIs.

Table 11: SC Theoretical KPIs by SMART Categories

		KPIs	Papers
Strategic	Customer Value	• Level of customer perceived value • Range of products and service	Gunasekaran *et al.* (2004)
	Total Cost of Ownership	• Variances against budget • Information processing cost • Net profit vs. productivity ratio • ROI	Gunasekaran *et al.* (2004); Lynch *et al.* (1991)
Tactical	Customer Satisfaction	• Number of complaints • Customer satisfaction rate • Customer intent to repurchase	Beamon, (1999); Shepherd *et al.* (2006); Lynch *et al.* (1991)
	Flexibility	• SC Responsiveness • Manufacturing/production/volume flexibility • New product flexibility • Purchasing flexibility • Logistics flexibility • Delivery flexibility • Mix flexibility	Beamon, (1999); Bolstorff *et al.* (2003); Chan *et al.* (2003); Cai *et al.* (2009); Prajogo *et al.* (2012)
	Cost + Productivity	• Capacity utilization • Value added employee productivity • Production cost • Total turnover cost • Information management cost • Supplier pricing against market • Total SCM cost • Distribution cost	Bartlett *et al.* (2007); Gustin *et al.* (1995); Chan *et al.* (2003); Angerhofer *et al.* (2006); Beamon, (1999); Bolstorff *et al.* (2003); Gunasekaran *et al.* (2004)
Operational	Quality + Technology	• Supplier quality level • Internal quality level • External quality level	Bartlett *et al.* (2007); Tse *et al.* (2012)
	Delivery (Service Level)	• Percentage of finished goods in transit • Percentage of on time delivery • Percentage of urgent deliveries • Rates of stock outs (losing sales)	Gunasekaran *et al.* (2004); Clark *et al.* (1997); Kulp *et al.* (2004)
	Time	• Manufacturing lead time • Order fulfillment lead time (cycle time) • New product development time • Supplier lead time against industry norm • Cash-to-cash cycle time	Handfield *et al.* (2002); Jayaram *et al.* (1999); Bolstorff *et al.* (2003);

	Waste	• 7 wastes
		  ○ Inventory
		  ○ Overproduction
		  ○ Correction
		  ○ Material & information movement
		  ○ Processing
		  ○ Waiting
		  ○ Motion
		• Obsolete products
		• Warranty cost
		• Shortage cost
			Lynch *et al.* (1991); Bolstorff *et al.* (2003); Lee *et al.* (1997a, 1997b, 2000, 2004), Yu *et al.* (2001), Disney and Towill (2003a, 2003b)

2.7 Conclusion of Chapter

By accurately summarizing the literature status quo, one is reassured that the researcher speaks with authority on the subject, demonstrating that enough knowledge and expertise within the field was gained to confidently make an argument. The research was defined, limited, and placed in a historical perspective. The definition by Mentzer *et al.* (2001) of SCM was chosen for this research and the SC goals were identified. Enough evidence was presented and groups of authors who draw similar conclusions were established to show that SC strategies are directly linked to SCP, given that they catapult competitive advantages. Five classifications of SC strategies were pointed out by literature and compared amongst each other, facilitating the decision-making towards the optimal strategy for VDL ETG (le-agile SC strategy).

Subsequently, PMS was defined and the activities it encompasses were determined. A large gap in literature review was identified when combining PMS specifically to SCM. Acknowledgement for the limited existing PMS frameworks was realized and three different frameworks were further analyzed. Here, a comparison and contrast between the different frameworks was established through tables of advantages and disadvantages, criticizing aspects of methodology. In attempt to close the gap pointed out, a SCPMS framework was developed, based on all the strong aspects of the three PMS frameworks, and named as the chosen SCPMS framework. The research context was taken into account when building such framework. A clear description of the different steps to take was elaborated and the frequency of execution per phase was made known.

For reasons already stated previously in this research, management cannot exist without measurement, so PMe played a critical part on this literature review since it represents the fourth step of the chosen SCPMS framework. The concept was defined and likewise the PMS, its goals were mentioned. Three frameworks were identified from literature and further analyzed. The quality of all frameworks was assessed based on the requirements drawn by literature, coming to the conclusion that the best suited is the SMART pyramid. Given the SC and high tech context of the case study, an adapted version of the SMART pyramid was presented, where all the alterations were justified.

Finally, based on the chosen theoretical SCPMeS framework, a list of KPIs were derived from theory and were accordingly grouped into the three different levels of the SMART pyramid, and additionally to the different categories of each level.

Given all the above information, and having summarized the state of the art of this research, the reader is now informed on why this research presents a unique angle compared to past studies performed on similar subjects.

3 Scientific Research Design

“Having identified the variables in a problem situation and developed the theoretical framework, the next step is to design the research in a way that the requisite data can be gathered and analyzed to arrive at a solution” (Sekaran, 2003). For this, one must decide on the most suitable options for the study design, based on the following: problem definition, research objectives and extent of rigor desired. This chapter deals with the data collection method, which is represented as block 5 of the research framework, in Figure 2. More specifically, it creates the basis for enabling the third research question to be addressed and answers the following sub-questions:

1. What are the most suitable options for the configuration of the research design?
2. How the empirical data gathered / which method or process is was followed?
3. Which bodies or respondents should take part and why?
4. What are the sources of data?
5. How is the data going to be analyzed?

3.1 Configuration of Research Design

Figure 6 schematizes the scientific research design where all configurations are derived from the characteristics described next. The purpose of the research, mentioned previously in Chapter 1 Section 1.5.2.2, is *exploration*. This type of study aims to develop enough bases for a better comprehension on the nature of the problem given that close to none studies have been conducted in the area of SCPMS at the high tech industry. Theory proposes that extensive interviews with bodies of respondents should be undertaken with the intention to get a better grip on the situation and understand the phenomena (Sekaran, 2003). Subsequently, a more rigorous research could then proceed.

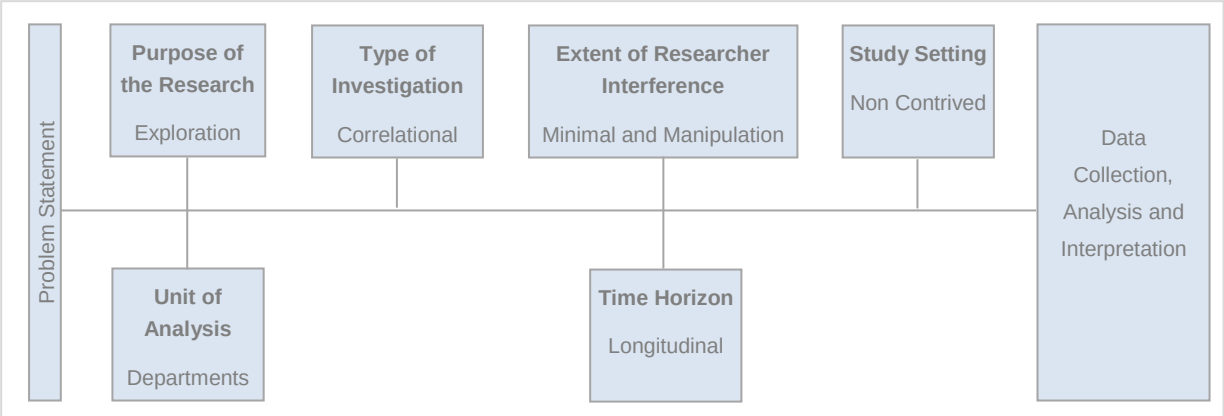

Figure 6: Scientific Research Design Configuration

In respect to the type of investigation, a *correlational* one is considered the best approach since the main interest of this research is to delineate the key variables associated with the problem. The extent of researcher interference is *minimal* at the AS-IS phase (the study is conducted in the natural environment of the organization with minimum interference by the researcher with the normal flow of work) and *manipulation* at the implementation stage (since the proposed frameworks will be

introduced and results will be entirely based on the output of these). It is important to note that the implementation stage does not encompass the scope of the dissertation.

Study setting is of a non-contrived nature where a field study takes place in the natural environment where work proceeds normally. Since the problem statement requires most departments' cooperation, and so, comparing different departments in the organization is a must, data analysis will be done at the departmental level. This means that individuals in the department will be treated as one unit so comparisons made treat the department as the unit of analysis. By studying phenomena at more than one point in time in order to answer the research question, one can study employees' behavior before and after a change (which in this case will be the adoptions of the chosen approaches at the implementation phase) so as to know what effects the change accomplished. Since data is gathered at two different points in time, the study is not cross-sectional or of one-shot kind, but is carried longitudinally across a period of time.

3.2 Data Collection Methods

Problems researched with the use of the appropriate methods greatly enhance the value of the research (Sekaran, 2003). Interviewing and observing people and phenomena are the main data collection methods in this research.

The establishment of a key stakeholder panel was made and it is represented in Table 12. The panel consists of VDL ETG's managing director, the SC manager and manager of new product introduction and optimization (NPIO) department, the group leader of supply chain engineers (SCEs) and new product logistics (NPL) engineers, production managers, program managers, purchasing manager, customer support (CS) manager, total quality (TQ) manager, cost controller (CC) and the human resources (HR) manager. All of the mentioned respondents are, to some extent, responsible for the successful management of the company's SC hence why being key stakeholders. Table 13identifies the function of each key stakeholder. Through this panel, several face-to-face interviews and meetings were held with the purpose of gathering information about what are the current PMSs and PMeSs being applied at VDL ETG, the AS-IS situation. This includes identifying what strategy and KPIs are in use at the present time. Subsequently, the TO-BE scenario is developed by introducing the chosen approaches for both frameworks and the KPIs which should be in place together with their relationships with one another. Finally, both situations are compared and the gaps between them are identified. Thorough meetings are then established to identify the outdated KPIs (ones that should be removed) and the 'must-have' KPIs (ones that should be added). To conclude, validation of both frameworks (PMS and PMeS) will be assessed.

3.2.1 Internal Data Review Process

Throughout the several steps and phases of this research, a discussion forum with the complete SCE team was developed to keep everyone up to speed and discuss the outcomes of every stage. The forum consisted of the group leader of the SCEs and five SCEs where several data was collected, in terms of: feedback, suggestions, opinions, feasibility of frameworks and advices.

Table 12: Key Stakeholder Panel

	SCE	Production	Purchasing	Sales	HR	Managing Director	Cost Control
Strategy	Edwin + Gerard	John + Michael + Ivo + Bert + Gerard H.	Christian		Harrie	Wil-Jan	Huub
KPIs							
Internal Value							
Customer Value		Ted + Paul + Jeremie + Gerard H.		Jeroen Boekema			

Table 13: Key Stakeholder's Name and Function

Name	Function
Edwin Leenders	NPIO & SC Manager
Gerard van Wandeloo	SCEs & NPL Group Leader
John Langenhuysen	Production Bureau
Michael van Vugt	Manager of Parts
Ivo Baijens	Factory Engineer Manager – Parts
Bert Koops	Factory Engineer Manager – Systems
Ted van der Meyden	Program Manager
Jeremie Besson	Program Manager
Paul van Oosterhout	Program Manager
Christian Rademaker	Purchasing Manager
Jeroen Boekema	CS Manager
Gerard Hermkens	TQ Manager
Wil-Jan Schutte	Managing Director
Harrie van Gerven	HR Manager
Huub Snelders	CC

4 Data Collection, Analysis and Interpretation

This chapter represents block 6 of the research framework, represented in Figure 2. As mentioned before, it is divided into three separate sections; AS-IS Case Description, TO-BE SCPMS and SCPMeS at VDL ETG, and the GAPS between the two previous sections.

4.1 AS-IS: Case Description

This section aims to get an accurate depiction of how business flows and what is in fact happening at the case company. Represented by block 6.1 of the research framework, it describes the currently applied SCPMSs and SCPMeSs at VDL ETG, answering research question 3(a). Although a brief introduction to the case company has been made in Chapter 1 section 1.3, a more thorough description is presented for the reader to gain further expertise about the company and to be critical about all arguments done hereby in this research. The following sub-questions are answered:

1. What is the company profile, what role does it play in the high tech industry, what is the mission and what are the key success factors?
2. What is the role of SCM within VDL ETG and its vision?
3. How is SCP measured and managed?

4.1.1 Company Profile

VDL Group is an international industrial company devoted to the development, production and sales of semi-finished products, buses & coaches and other finished products, and the assembly of cars (VDL Group, 2015). In 1953, with the establishment of 'Metaalindustrie en Constructiewerkplaats P. van der Leegte', the foundation was laid for what is now VDL (Van Der Leegte) Group. Starting with five employees in a humble building in Eindhoven, it now consists of 85 operating companies with approximately 10,000 employees working in 19 different countries around the world with a turnover of 1,812 million Euros in 2013.

VDL ETG was founded in 1900 as Philips Machine Factories and during the 20th century it became a worldwide operating company, supplying integrated systems and solutions to Philips as well as to other companies. In 2000, the name changed into Philips Enabling Technologies Group and in 2006 it was taken over by the VDL Group (VDL ETG, 2015).VDL ETG focuses on reaching global leadership as tier-one contract manufacturing partner by outperforming in delivering mechatronic solutions. This is achieved by the set of competences, processes and products provided by VDL ETG, which belong to the company's DNA, demonstrated in Figure 7. As one can see, SCM is one of the processes which constitute this DNA. Section 4.1.2 explains the role of SCM at VDL ETG.

As a contract manufacturing partner, VDL ETG focuses on quality, logistics, technology and cost (QLTC) performance which is the life line of the company. The correct balance of the QLTC aspects combined with the competences and knowledge offered by VDL ETG enable services for its customers through the complete life cycle of their products.

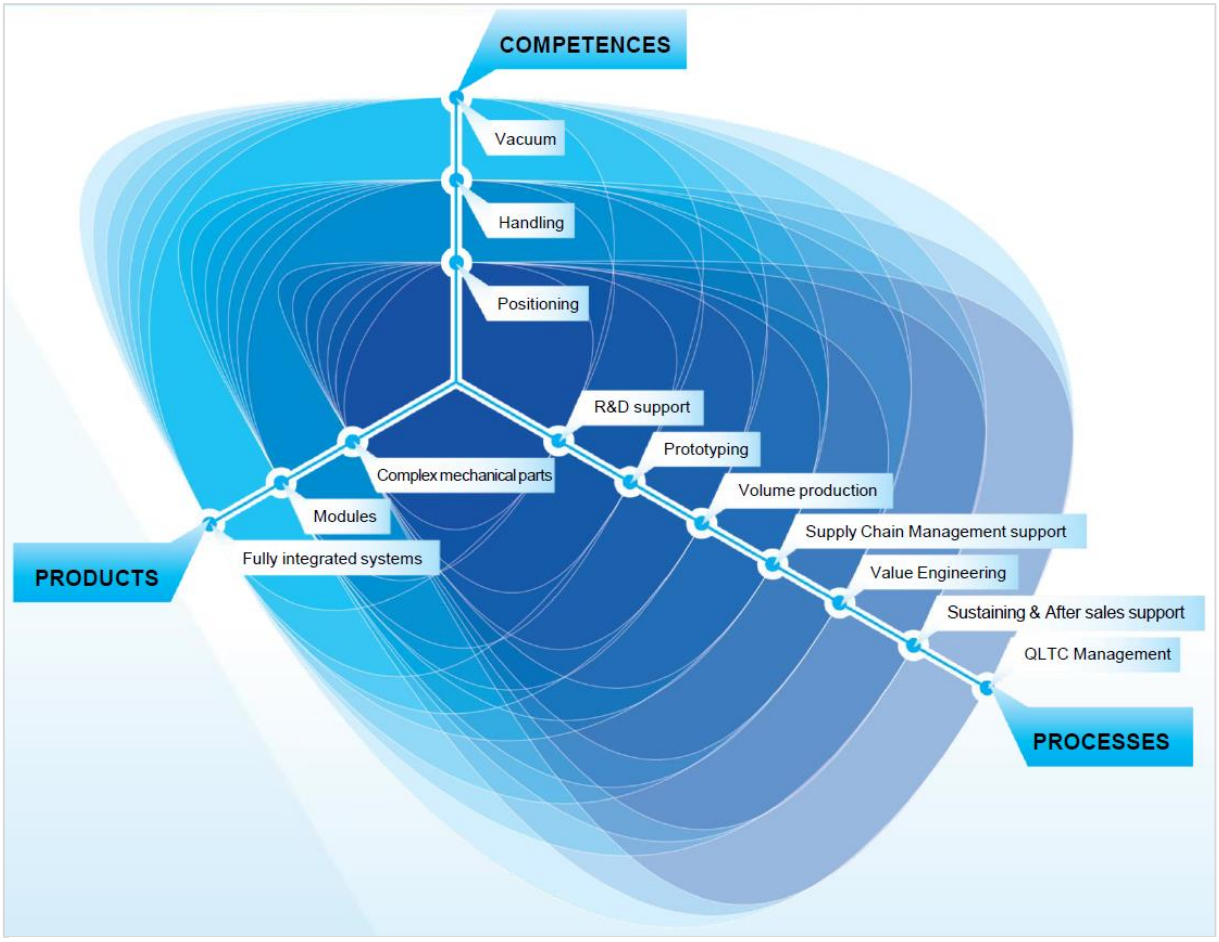

Figure 7: VDL ETG's DNA. Source: Internal VDL ETG documents

To define what the key success factors of VDL ETG are, three meetings were carried out with the program managers responsible for the major customers. Here, the customer requirements were made known and the reasons as to why these customers choose VDL ETG as a supplier were identified. Results are available in Table 14. Every customer has its own specific requirements derived from the market in which they are inserted, characteristics of the product they produce, etc. Exceeding customer requirements by not only offering steadiness in QLTC performance but also by providing strong knowledge of ASML's know-how (when VDL ETG supply to ASML's suppliers), development services from the initial phase of a product, copy exactly knowledge, etc., make up the company's key success factors and strongly contributes for enabling it to be a business differentiator.

4.1.2 SCM at VDL ETG

At VDL ETG, SCM activities are within the NPIO department, just like represented in Figure 8. This is due to the fact that NPIO is involved in the entire product generation process (PGP) (from feasibility of a product to extended service), so this is where SCM fits best compared to other departments.

The current SCM vision is "to be the enabler for VDL ETG customers to fulfill excellent global SCM along the product lifecycle". To accomplish this, the SCM team is responsible for monitoring cost price and cycle time and initiating actions to reduce these two. They also generate overviews about cost reductions for other departments like purchasing, parts and systems. Other responsibilities include implementation of vendor managed own inventory (VMOI), fixed pricing and forecasting agreement.

Involvement in the product family teams is also a task assigned for the SCEs, as well as internal improvement projects (like implementing lean on the welding lines), process development, etc.

Table 14: Requirements and key success factors by customer

Customer	ASML	Philips Medical Systems	Trumpf	Thermo Fisher	FEI	Waters
Requirements by Customer	Low cost and maximum efficiency.	Stable production, flexibility in terms of demand, copy exactly, quality.	Know-how of ASML's products.	Flexibility (demand is very volatile). Note: VDL ETG works with annual orders, meaning high purchasing commitment and high stocks.	Technology, which fits perfect at VDL ETG's DNA. Cost reduction is also a must.	Technology and cost
Key Success Factors	Flexibility, quality and now development.	Quality, flexibility and copy exactly.	Flexibility and VDL ETG's know-how on ASML's products is best added value.	High added value is cost, flexibility in logistics, quality and technical performance.	Technology. VDL ETG is good at discussing QLTC and showing more options than the normal routes.	Technology. Cost pressure not that high compared to FEI.
Is VDL ETG a preferred supplier?	Yes	Yes	Yes	Yes	Yes	Yes

4.1.3 Current KPIs in Place to Measure SCP

As mentioned in Chapter 3, interviews were done with the key stakeholder panel to identify the AS-IS situation as to what KPIs are currently being measured and how frequently they are being revised. Results are demonstrated in Figure 9 where the KPIs have been allocated to the corresponding category and are clearly differentiated by color, referring to what department/owner they belong to. The listed KPIs represent the ones that make sense for the SCM context so this overview does not include all the KPIs in place at VDL ETG, since some of them are too specific and of unnecessary detail for this purpose.

4.1.3.1 Strategic Level Category – Customer Value

It is interesting to acknowledge that currently, there is not even one KPI measuring customer value. Key stakeholders mention it is too difficult to measure such aspect.

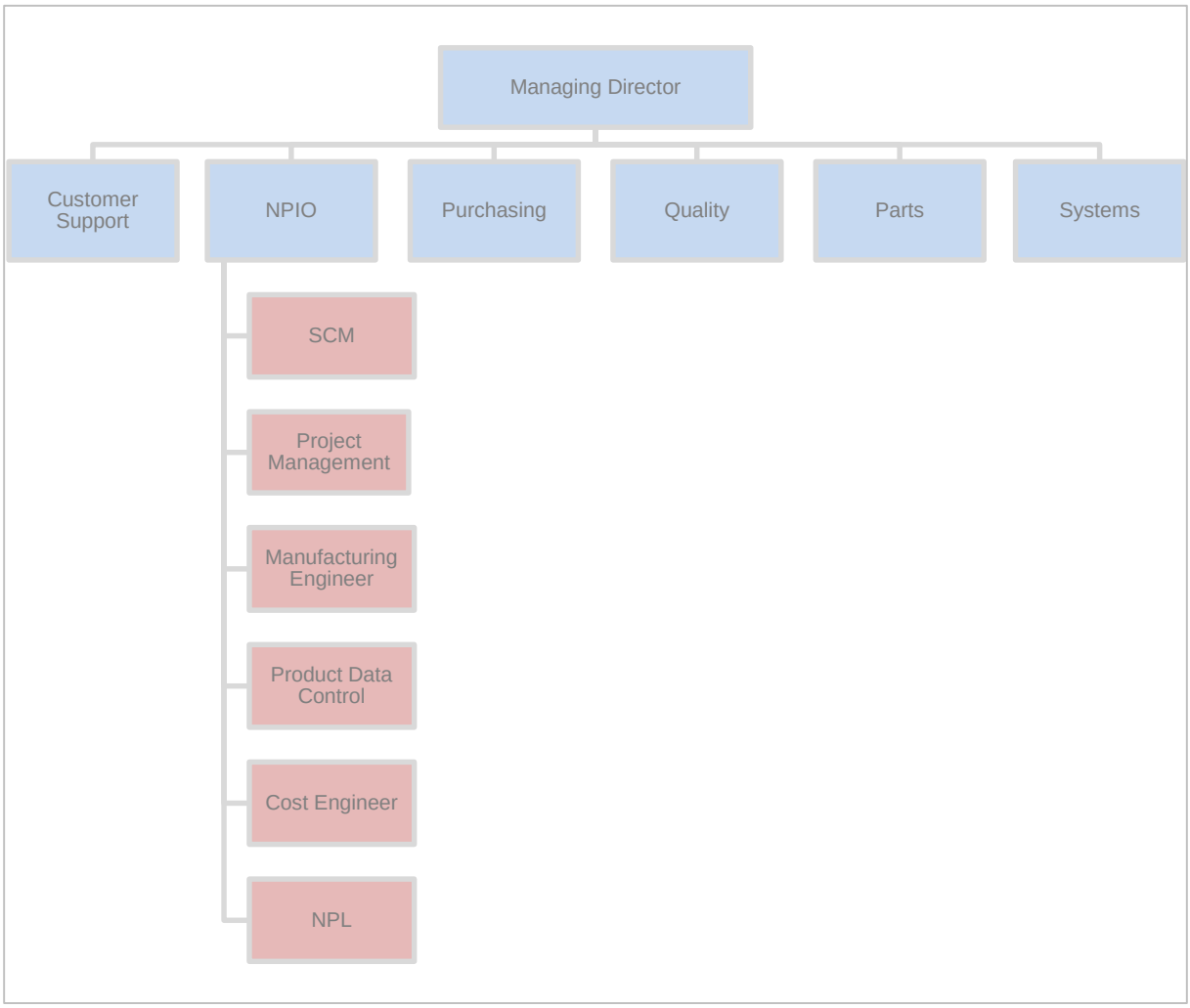

Figure 8: Organizational Structure and SCM within VDL ETG

4.1.3.2 Strategic Level Category – Total Cost of Ownership (TCO)

This category is mainly 'owned' by the Cost Control Board (CoCoBo), with one KPI for the CS Department. The following KPIs are in place:

- **Turnover**: annual sales volume net of all discounts and sales taxes;
- **Gross Profit**: takes into account the sum of; recalculations results, sales results, material consumption results, coverage results, waste production, extraordinary income, variance of stock levels and number of hours overload;
- **Hour Rate**: the amount charged to customers per hour booked in projects;
- **Overall Margin**: average of all margins per customer.

Stakeholders belonging to the CoCoBo and CS department believe these 4 KPIs give a good view on how TCO is performing. Gross profit and overall margin can be interpreted as being the same KPI but since all attention at VDL ETG nowadays is in costs, a more detailed view is preferred, hence the existence of both KPIs.

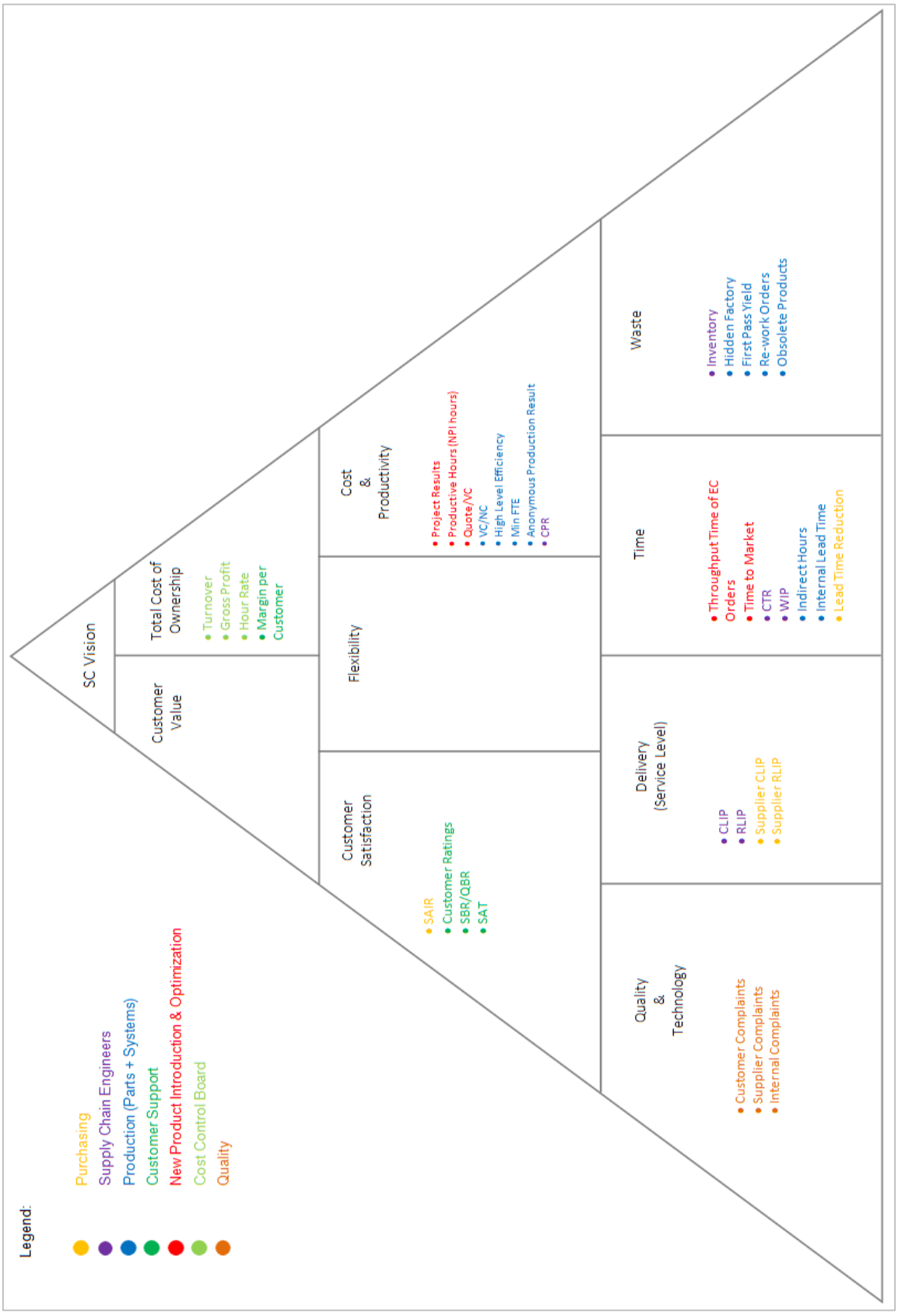

Figure 9: AS-IS KPIs

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4.1.3.4 Tactical Level Category – Customer Satisfaction

Department of Purchasing and CS are responsible for this category.

- **Supplier Assessment and Improvement Review (SAIR)**: this KPI is self-explanatory and scores each supplier. It is clearly understandable that a poor classification on this KPI impacts the overall end customer satisfaction;
- **Customer Ratings**: assesses how VDL ETG ranks according to its customers, also presents itself as a crucial KPI for this category;
- **Strategic Business Reviews (SBR) / Quarterly Business Reviews (QBR)**: keeping track of whether account managers are assisting customers with these type of reviews;
- **Strategic Advisory Teams (SAT)**: being aware if teams are assigned for each customer to help customers with strategic advices in terms of development, plans modification, etc.

4.1.3.5 Tactical Level Category – Flexibility

Likewise the customer value category, flexibility is also empty. This can be explained by the fact that VDL ETG has the QLTC way of working, where flexibility falls into the logistics part and there are no KPIs that relate specifically to flexibility itself. Nonetheless key stakeholders are aware that this is an issue and acknowledge that this hole needs to be filled in.

4.1.3.6 Tactical Level Category – Cost & Productivity

The main owners of this category are the NPIO and production (Parts + Systems) department. Moreover, program managers play a small but key role.

- **Project Results**: profit resulting from every project;
- **Productive Hours**: number of hours spent in each project;
- **Quote/Voorcalculati (VC)**: difference between the quoted values of projects compared to what is actually estimated by the manufacturing engineers;
- **VC/Nacalculati (NC)**: difference between the estimated cost of project compared to what it actually ended up costing;
- **High Level Efficiency**: if the hours assigned for production of each item is being met (productive hours of production department);
- **Minimum Full Time Equivalent (FTE)**: minimizing workload for cost reduction;
- **Anonymous Production Result**: amount of production related to items that can be used in several product making;

- **Cost Price Reduction (CPR)**: measuring if reductions in the cost price are meeting the target. This is not really a KPI since there is no formal document where all information regarding cost price reduction can be found in an overall view. What is currently happening at the case company is that each SCE has its own projects from specific customers and they monitor how the actions for cost price reduction are performing according to customer requirements. Nevertheless it is included in the AS-IS situation.

4.1.3.7 Operational Level Category – Quality & Technology

Surprisingly, as being a high tech company, VDL ETG does not keep track of any technology KPIs. They have a technology roadmap but assessing whether targets are being met is not done. So, this category is consisted of only quality related KPIs henceforth the only owner is the quality department:

- **Customer Complaints**: number of customer complaints reflects directly on the satisfaction of the customer, hence presenting itself as the most important KPI for this category;
- **Supplier complaints**: these are the complaints VDL ETG has towards its suppliers. Currently the purchasing department also takes track of this KPI but due to different interpretations by the purchasing manager and the total quality manager (not specified), it has been decided that they will each measure it;
- **Internal complaints**: represent all internal complaints within VDL ETG.

4.1.3.8 Operational Level Category – Delivery (Service Level)

Purchasing department and the SCEs share the ownership of the KPIs that fall in this category. The KPIs are the following:

- **Confirmed Line Item Performance (CLIP)**: delivery performance of orders against the committed delivery date;
- **Requested Line Item Performance (RLIP)**: delivery performance of orders against the requested delivery date;
- **Supplier CLIP**: supplier's delivery performance of orders against the committed delivery date;
- **Supplier RLIP**: supplier's delivery performance of orders against the requested delivery date.

4.1.3.9 Operational Level Category - Time

KPIs related to time are found in a couple of departments at VDL ETG like: NPIO, Parts + Systems, and Purchasing. Moreover, within the NPIO department, the SCEs have full responsibility on some KPIs, like cycle time reduction (CTR) but they are only monitoring this information. Furthermore, this monitoring is done on a customer level and not as an overall value so technically it is not a KPI but since there are individual customer target for this information, CTR is included in the AS-IS pyramid. Here are the descriptions of this category's KPI list:

- **Throughput time of Engineering Change (EC) orders**: measures how many weeks are required to execute an EC order;
- **Time to Market**: this indicates the length of time it takes to get the product form the concept phase into market or end customer;
- **Indirect hours**: hours that are not paid by the customer directly, the general manager provides a budget and then accounting team deducts this cost from the margin of the customer;
- **Internal lead time**: the length of time spent from placing an internal order (to production) to the delivery of that order;
- **Lead time reduction**: the length of time spent from a customer placing an order to the delivery of that order;
- **Work in Progress (WIP)**: this represents all € that are invested in production process. It is NC plus openstaande verplichtingen (OV) which means all costs associated with processes that

have already been done (so actual cost can be calculated) plus all remaining processes needed to occur for the finalization of the product (where only estimated costs are known).

4.1.3.10 Operational Level Category – Waste

The majority of the KPIs in the waste category belong to Parts and Systems departments, with only one belong to the SCEs (inventory). Here follow the KPIs:

- **Inventory**: inventory levels, typically VDL ETG strives always to lower this KPI to its minimum;
- **Hidden factory**: all costs associated with everything that is not in the production or purchasing order;
- **Re-work orders**: number of orders that incur from correcting something in a product;
- **First Pass Yield (FPY)**: Number of production orders that are not according to requirements the first time they are produced;
- **Obsolete products**: the number of products that, in a given period, become obsolete (no longer wanted by customers because it may be outdated or there might be a better option than it). This is a very important KPI for the high tech industry since PLC is very short, which means that products laying in inventory for a long time can easily become obsolete.

4.1.4 Performance Reporting and Management

Managers collect data for measuring KPIs from the ERP system in place and the data gathering business intelligence platform which is updated every night. Each department gathers all the data and develops a KPI dashboard where the state of all KPIs is assessed and performance trends are identified over time. Most of the dashboards include the 'traffic lights' method goals, where one can easily identify if one KPI is meeting the target or not. Values appear in green when it matches the target (or surpasses it), a yellow value appears when it is relatively close to the target, and a red value shows up when it's below the target. Almost all target values are set based on manager's gut feeling and experience.

KPIs are reviewed weekly, monthly or quarterly by each department, individually, and the dashboards are updated. It is important to make known that the SCEs do not have any sort of dashboard to keep their KPIs on track, in fact, they are only monitoring the KPIs mentioned in Figure 9, not reviewing or revising them for improvement initiatives. There is no general dashboard where all departments place their information about their KPIs in and therefore, where one could get an overview of the entire company.

4.2 TO-BE: SCPMMSs at VDL ETG

Post the AS-IS mapping, the TO-BE scenario is developed. This section is identified in the research framework as block 6.2 (Figure 2) and often aims to present the 'perfect future' which will gain shape by constraints from the context and culture of the case company. In order for one to achieve this aim, the first iteration at the TO-BE section should focus on achieving the objectives predetermined in section 1.2. In view of this, the TO-BE scenario is elaborated based on the chosen SCPMMSs framework previously described in Chapter 2, where the optimal theoretical solutions (the ideal KPIs to measure in each block) found in literature review are incorporated. This answers research question 3(b) and the sub-questions answered are listed below:

1. What should be the vision of internal SCM at VDL ETG?
2. Which performance metrics should be used?

3. How should the reporting structure and control loop be defined?

4.2.1 Proposed Internal SCM Vision

In the preliminary semi-structured interviews done in the initial stage of this research, the key stakeholders gave their input towards the SCM vision at VDL ETG. Taken that into account and after meeting with the entire stakeholder panel, the following internal SCM vision is proposed:

> *"To practice world leading supply chain management activities to enable state-of-the-art technologies for VDL ETG's customers by playing a decisive role in delivering exceptional mechatronic solutions."*

In order to become a business differentiator, Tyndall & Kane (2012) propose the following top seven success factors for value creation in terms of SC priorities for the high tech industry: the right operations strategy, effective business processes and people, integrated business planning and execution, demand-driven operations, optimized logistics, new and powerful technology, and SC risk management.

4.2.2 New KPI Definition Template

Since all departments at VDL ETG create their own dashboard and review the information in an independent way, there are several templates for defining new KPIs when necessary. This creates a mass confusion and therefore a KPI definition template is proposed in order to standardize this process, available later in this research. Having a uniform template for the entire company makes it easier for stakeholders to have a similar interpretation of the information and therefore 'speak the same language'.

4.2.3 TO-BE SCPMeS

In order for VDL ETG to achieve the objectives predetermined in section 1.2 and taking into account what was derived from literature review and considered the chosen optimal SCPMeS for the high tech industry, the following performance pyramid is constructed, shown in Figure 10. This performance pyramid also takes into account the 'nice to have' KPIs mentioned by the key stakeholder panel when realizing the data collection interviews. All KPIs that showed little relevance for the case company were eliminated.

4.2.3.1 Strategic Level Category – Customer Value

It is not easy to measure a relationship. Customer value is by far the most challenging category in the performance pyramid since it is difficult to put a number or percentage on it. To overcome this problem and in attempt to fill in the hole in this particular category, the following two KPIs were derived by discussion with the Customer Support Manager:

- **Relation**: conducting questionnaires to customers to assess the overall relation, in order to come up with an estimate as to how VDL ETG is being perceived by them. This can be done based on the principle of the trust equation, where trust equals the sum of reliability, credibility and intimacy divided by the self-orientation. This is all based on how customers perceive the

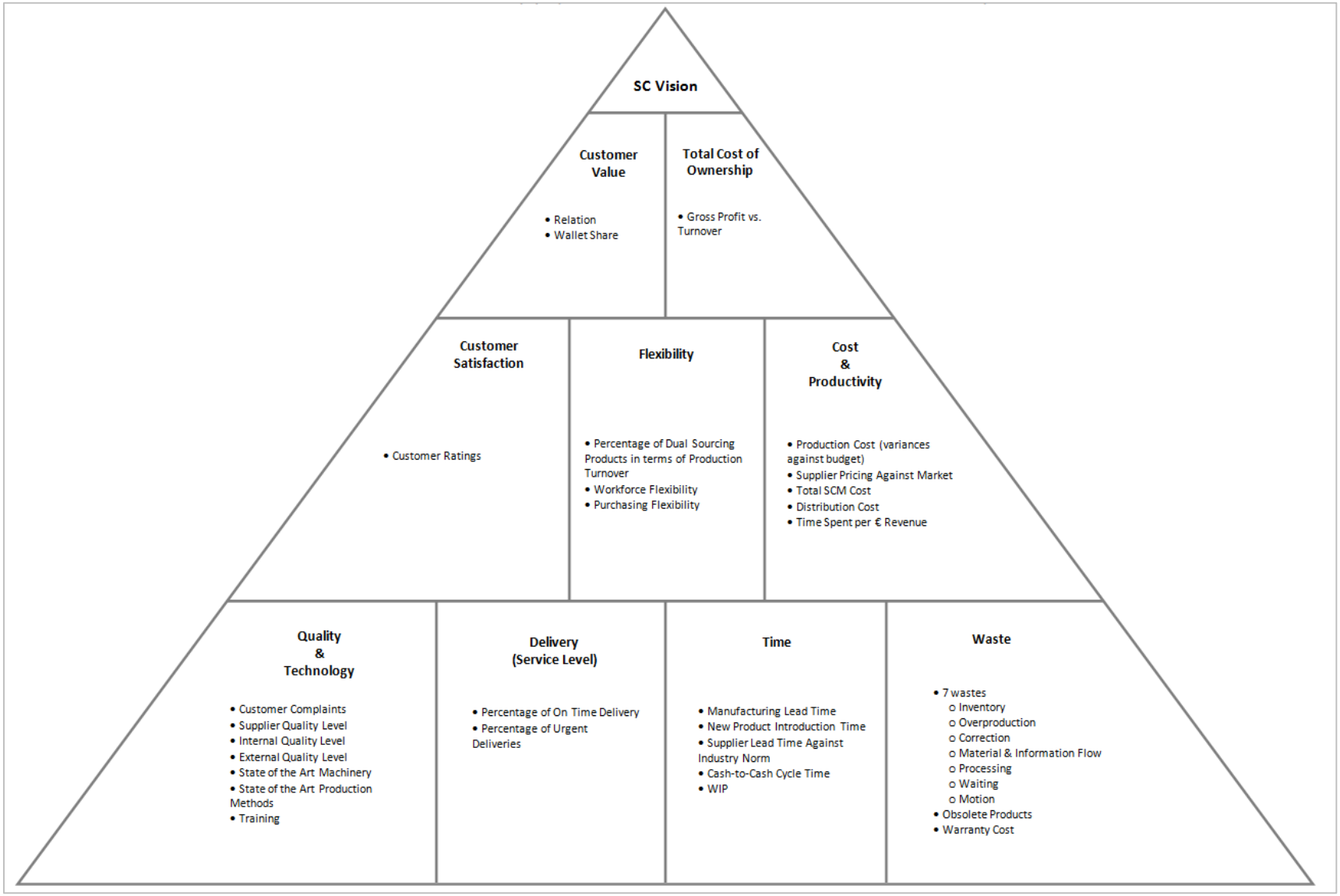

Figure 10: TO-BE KPIs

company in those aspects. Reliability has to do with actions (if VDL ETG agrees on a delivery date, to what extent do customers believe in that fulfillment), credibility has to do with words (if VDL ETG has certain features which make all communications through words seem credible to the customer), intimacy is the safety or security perceived by the customer when entrusting VDL ETG with its projects/modules, and self-orientation is whether VDL ETG's focus is primarily on itself or on the customer.

- **Wallet Share**: assessing the percentage of spending that customers make at VDL ETG for the specific products it offers is a good way of understanding to what extent there is more business development opportunities with that customer. It also gives a better view of resource allocation.

4.2.3.2 Strategic Level Category – TCO

For this category there were some KPIs derived by both the researcher and some stakeholders in several discussions. The existing ones are considered enough to provide a clear overview on how the company is doing financially speaking but, nonetheless, from theory, the following KPI is considered a must have:

- **Gross Profit vs. Turnover**: analyzing the percentage of profit in relation to the turnover, taking into account that the case company performs in the high tech industry.

4.2.3.3 Tactical Level Category – Customer Satisfaction

All KPIs related to customer satisfaction should be in place in this category. Even though literature review indicates that this category should contain a KPI that measures customer complaints, stakeholders find it a better metric for the quality and technology category, remaining in this category. The metrics within this category have been described previously in section 4.1.3.4.

4.2.3.4 Tactical Level Category – Flexibility

When discussing what the ideal KPIs specific for flexibility should be, and after having realized that VDL ETG has no specific KPIs for this category, here are the KPIs derived by theory and the many discussions made during data collection:

- **Workforce Flexibility**: whether workforce is able to be flexible due to fluctuating demand;
- **Purchasing Flexibility**: if changing suppliers is a possibility and to what extent;
- **Percentage of Dual Sourcing Products in terms of Production Turnover**: this takes into account the percentage of production turnover that is composed of products that can be dual sourced (internally made or outsourced) and VDL ETG has all processes in place to do so.

4.2.3.5 Tactical Level Category – Cost & Productivity

For this category, the following KPIs are derived from the several sources of data collection:

- **Production Cost**: mainly identifying variances against budget;
- **Supplier Pricing Against Market**: assessing if the suppliers are practicing normal pricing;
- **Total SCM Cost**: cost of all goods;
- **Distribution Cost**: all distribution costs;
- **Time Spent per € of Revenue**: measuring the amount of time per customer and how much that customer contributed to the revenue.

4.2.3.6 Operational Level Category – Quality & Technology

The KPIs derived for this category are the following:

- **Customer Complaints**: already described in section 4.1.3.7;
- **Supplier Quality Level**: how well the supplier performs in terms of quality;
- **Internal Quality Level**: how well the company is performing on quality levels;
- **External Quality Level**: how the quality delivered to customers is perceived;
- **State of Art Machinery**: highest level of general development of machines being used;
- **State of Art Production Methods**: most innovative production methods being implemented according to customers' requirements;
- **Training**: if trainings are taking place.

4.2.3.7 Operational Level Category – Delivery (Service Level)

KPIs specific for this category are the following:

- **Percentage of On Time Deliveries**: whether delivery dates are being met;
- **Percentage of Urgent Deliveries**: whether urgent deliveries are being met.

4.2.3.8 Operational Level Category – Time

Here are the KPIs derived for the category of time:

- **Manufacturing Lead Time**: total time required to manufacture a product/item;
- **New Product Introduction Time**: total time required for a new product to be processed, from idea to production;
- **Supplier Lead Time Against Industry Norm**: measuring if the time required to place an order at a supplier until the date of delivery to VDL ETG is within the normal lead times of other suppliers the high tech industry;
- **Cash-to-Cash Cycle Time**: total time that operating cash is out of reach for use by the case company.

4.2.3.9 Operational Level Category – Waste

The non-added value KPIs considered the ideal ones to provide a clear overview on this category are the following:

- **Inventory**: inventory levels;
- **Overproduction**: amount producing more than needed and faster than needed;
- **Correction**: inspection and/or repair of a product;
- **Material & Information Flow**: any material or information movement;
- **Processing**: effort which adds no value to the product from the customer's perspective;
- **Waiting**: Idle time created when people wait for machines, people wait for people, machines wait for people, and machines waiting on machines;
- **Motion**: any movement of people or machines;
- **Obsolete Products**: already described in section 4.1.3.10;
- **Warranty Cost**: costs to assist and/or repair any damaged product delivered to customers.

4.2.4 Performance Reporting and Management

The chosen SCPMS enters in action here, more specifically, step 5 where the performance levels are monitored, audits are done to see if targets are being met, reviews and improvement initiatives are executed, reports are consolidates and benchmark should be done.

4.3 GAPS: Action Plan

This section is an attempt to answer question 3(c) of the research questions. Having identified the AS-IS situation as to what KPIs are currently in place at VDL ETG and identifying the ones relevant for the scope and detail required, the proposed TO-BE situation was made known, with all KPIs derived from

theory and the ones key stakeholders find interesting to have, together with the ones that are a ‘must have’. The following step is to identify the GAPS between these two scenarios, decide the top priority gaps to be closed, close these gaps and reach into a final performance pyramid for VDL ETG to use when the intent is to measure SCP. This phase is represented as block 6.3 from Figure 2 and serves also as a closure for the data collection, analysis and interpretation milestone. The following sub-questions are answered:

1. What measures should be added to the AS-IS situation?
2. What is the final SCPMeS?
3. What are the top priority gaps to be closed?
4. How will these gaps be closed?

4.3.1 Final SCPMeS

After comparing the AS-IS and TO-BE performance pyramids, the following draft of the final version of the SCPMeS is created, demonstrated in Figure 11. This pyramid represents all KPIs that are already in place, together with the KPIs drawn from literature and lastly, the KPIs that are considered a ‘must have’ from the key stakeholders. The new KPIs are identified by the pink color and this new performance pyramid contains a more thorough and robust set of KPIs, making it possible to get a more descriptive view of what is affecting the SCP.

To derive the final version of the SCPMeS for VDL ETG, several discussions took place with the key stakeholders and the researcher. The main aim of the discussions was to eliminate all the redundant KPIs and the ones that were not really bringing any new input about the SCP. Another aim was to arrive at the minimum number of KPIs as possible, since the key stakeholders showed some concern about having too many metrics and the confusion that can result from this. Even though it was a difficult process to come to the final version of the SCPMeS, since some stakeholders showed a lot of resistance to change, the final SCPMeS is shown in Figure 12. The alterations from the draft version to final version are explained next. It is crucial to say that the highest priority for the moment is to fill in the gaps identified, so the high priority KPIs to be implemented are the ones related to the categories of customer value and flexibility (implementation of relation, wallet share and dual sourced products KPIs).

4.3.1.1 Strategic Level Category – Customer Value

This category had no KPIs in the AS-IS situation hence it represents a big gap and the aim is to close it. This will be achieved by implementing the KPIs of Relation and Wallet Share. Further explanation is granted later in this chapter.

4.3.1.2 Strategic Level Category – TCO

No changes for the TCO category.

4.3.1.3 Tactical Level Category – Customer Satisfaction

Since the scope of this research is to develop the design for implementation of internal SCPMMSs, the SAIR KPI is eliminated. Key stakeholders believe that if this metric indicates a bad performance, it will directly affect customer ratings, so they opted to just include the later one. SBR/QBR and SAT were eliminated since there is nothing to stir on regarding these KPIs. Even if there are SBR/QBR and SAT

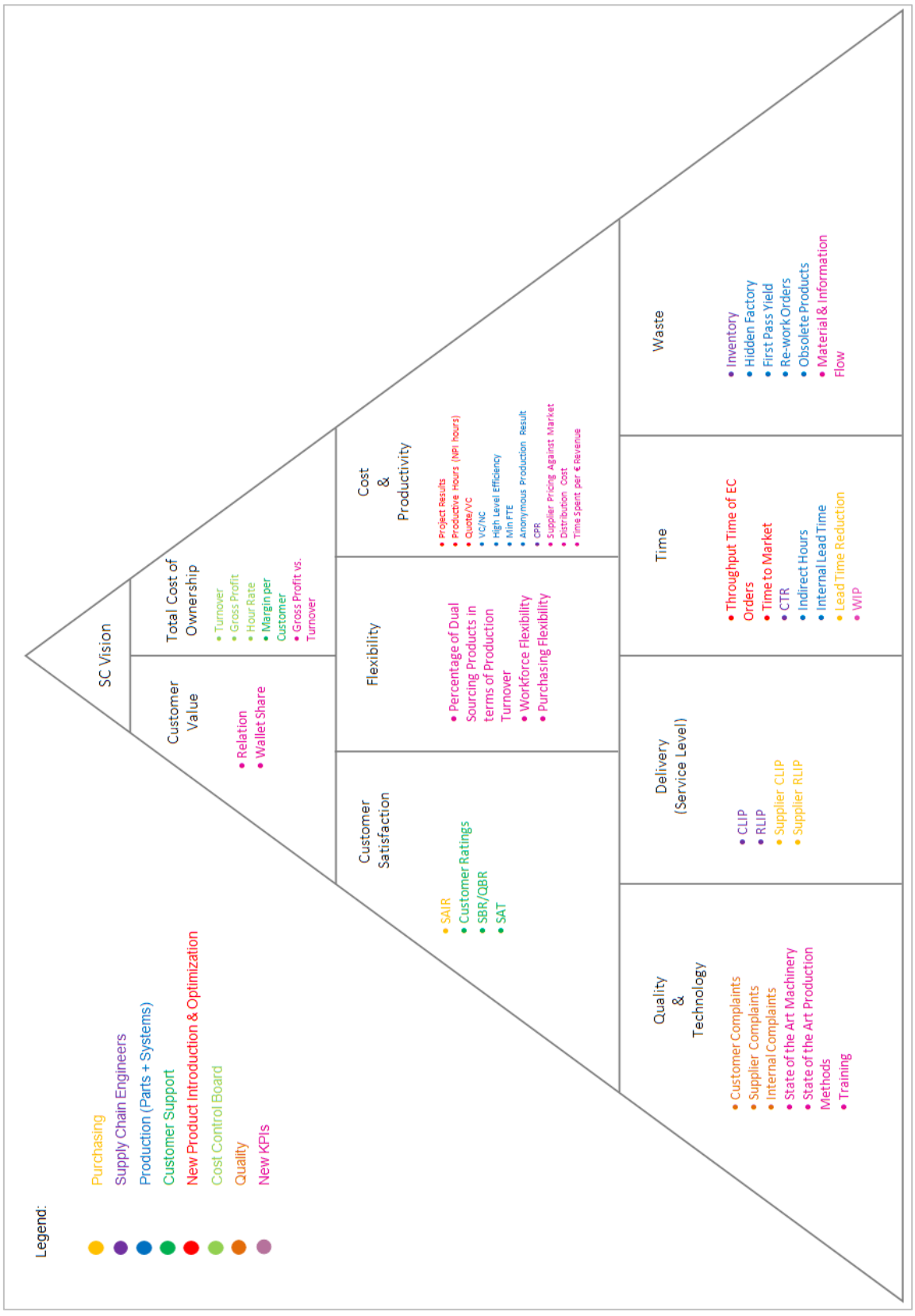

Figure 11: Draft of Final Proposed SCPMeS

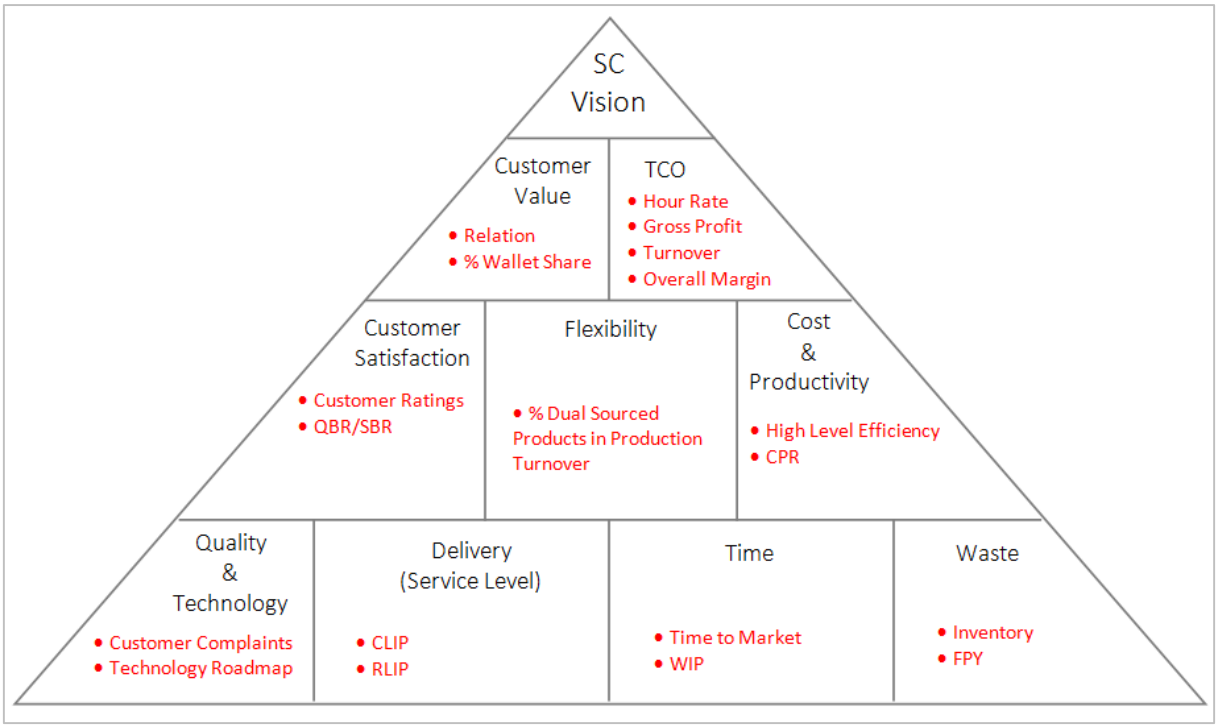

Figure 12: Final Version of VDL ETG's SCPMeS

for each customer account at VDL ETG, that is not directly linked to customer satisfaction. In view of this, customer ratings is the only KPI in this category at the final version of the performance pyramid.

4.3.1.4 Tactical Level Category – Flexibility

Likewise customer value category, flexibility is the other big gap identified and, therefore, presents itself as a high priority gap to be closed. The percentage of dual sourced products in the production turnover is the chosen KPI to implement and to close the gap. Workforce flexibility was excluded in this initial phase due to the fact that stakeholders believe that it can be incorporated into the dual sourced KPI. Purchasing flexibility does not represent a big priority for now so it was also not included. Production manager is very confident that the dual sourced KPI will be a big success to identify how flexibility is performing and to ultimately aid in decision making regarding the make-buy decisions.

4.3.1.5 Tactical Level Category – Cost & Productivity

Although this was the category that was subject to the most KPI eliminations, key stakeholders believe that the final version is sufficient to identify the performance of this category. Project results, productive hours, quote/VC, VC/NC, minimum FTE and anonymous production result were all removed, since they represented redundancies towards the high level efficiency KPI. All these KPIs that were eliminated are taken into account when reaching the values of high level efficiency so they are not necessary for this company overview. All the new KPIs that are derived from theory or considered ‘must have’ by key stakeholders, are not included in the final version of the SCPMeS since there are higher priorities for now. Given all the above, the KPIs that will remain are the cost price reduction and high level efficiency.

4.3.1.6 Operational Level Category – Quality & Technology

Just like it was mentioned in section 4.3.1.3 our scope is the internal SC so supplier complaints and internal complaints are eliminated. Key stakeholders are confident that the KPI for customer complaints can give an overview on how these other two KPIs are performing so for this high level, such detailed KPIs are not necessary. Section 4.1.3.7 states that VDL ETG has a technology roadmap but no one is assessing whether targets are being met. For this reason, the new proposed KPIs are not included since the key stakeholders find this a good opportunity to start making targets and keeping track of them regarding the technology roadmap. So, this category is composed of the following KPIs: customer complaints and technology roadmap.

4.3.1.7 Operational Level Category – Delivery (Service Level)

CLIP and RLIP are the only KPIs that made it to the final version of the delivery category because, as it was mentioned in sections 4.3.1.3 and 4.3.1.6, the scope of the research is the internal SC.

4.3.1.8 Operational Level Category – Time

Some KPIs were eliminated in this category. Throughput time of EC orders is one of them, and it was removed because it represented a redundancy towards the KPI of time to market. Indirect hours, internal lead time and lead time reduction were also removed because key stakeholders believe they do not provide the desired high level overview. Given this, the KPIs that make up the category of time are the following: time to market and WIP.

4.3.1.9 Operational Level Category – Waste

For the final version of this high level overview of a SCPMeS for VDL ETG, the KPIs that are included in the category of waste are inventory and FPY. Hidden factory and re-work hours are redundant to the FPY KPI hence being removed. The new proposed KPI, material & information flow, is also removed because there are higher priorities for this moment. Obsolete products was eliminated because key stakeholders are confident that this level of detail is not necessary for this performance pyramid.

4.3.2 Implementing Top Priority KPIs

After analyzing the gaps between the AS-IS performance measurements in place at VDL ETG with the desired TO-BE scenario, it is easily understood that the top priority gaps to close, or in other words, the top priority KPIs to implement, are the ones belonging to the empty categories in the AS-IS case. These KPIs are: relation and wallet share (from the category of customer value) and percentage of dual sourced flexibility in PARTS production (from the category of flexibility). Next, the implementation of each KPI is described.

4.3.2.1 Implementing Relation KPI

It is not easy to assign a number to a relation but one can try. To discuss how this could be successfully done, some meetings took place with the manager of CS department, the general director and the researcher. The main conclusion drawn was that the best procedure to put into practice to assess how customers perceive VDL ETG is through questionnaires. Plus, these questionnaires should be based on the trust equation developed by Charles H. Green, shown in Figure 13 (extracted

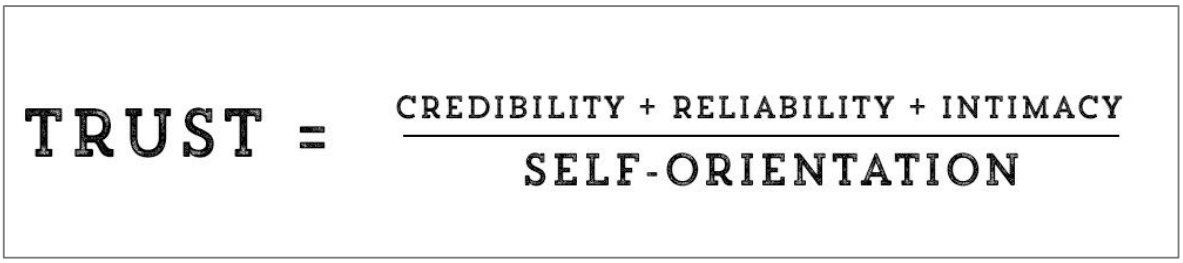

Figure 13: Trust Equation, by Charles H. Green

from *www.trustedadvisor.com*). Charles is the founder and CEO of Trusted Advisor Associates, an organization of leadership consultants with the goal of improving companies' relationships with customers, increase their sales, maximize their team performance and help leverage their strengths.

The trust equation is made up of four principles; credibility, reliability, intimacy and self-orientation. Credibility is about the words that the company speaks to the customer and assesses whether the customer believes in what is being said. Reliability has to do with actions and commitments made. For example: if VDL ETG has agreed on a delivery date, to what extent do customers believe this delivery will be made? Intimacy is the safety or security perceived by customers when entrusting VDL ETG with their products. Self-orientation, on the other hand, assesses if VDL ETG's focus is primarily on itself or on the customer. The more credibility, reliability and intimacy and the less self-orientation, the higher the trustworthiness will be.

The trick is to incorporate this concept of trust and its different components into questionnaires and once this is established, VDL ETG achieves the benefits of learning how to build trust in relationships with customers, insight to improve opportunities and benefit from valuable tools to build trust and business. Ideally the questionnaires will be made up of five sections, one for each component and a final one with an overview. Each section would focus on the corresponding component by a couple of questions directed to that component. Answers could be on a numerical scale from one to five (one being the lowest score and five being the highest) so for each section, there would be an average score, which will then be placed in the correct place of the trust equation to arrive at the final value of trustworthiness.

Taking into account that to develop these questionnaires, put them into practice by asking customers to respond, waiting for feedback and arriving to conclusions, is a process that can easily take at least six months to be completed. Given the time frame of this study and the minimum duration of questionnaires implementation, it is unfeasible to implement this KPI. Once this was realized by the researcher, ways to work around this problem were though about. For the time being, and to serve as an indication of how the case company is performing in the customer value category, instead of assessing relation, the "quick-fix" is to assess perceived relation. Perceived relation is assessing how the manager of CS perceives the relation between customer and VDL ETG. This, however, does not fully substitute the relation KPI initially intended to implement and will be mentioned in the recommendations and future work section at the end of this research as a highly recommended to-do action.

To measure perceived relation, a numerical scale from one to four was used (one being the indicator of a bad relation and four the indicator of an excellent relation). A table with the top nine customers

was made and all the CS manager had to do was to fill in the perceived relation. Since this is a KPI that is assessing value of a relation, it does not require a very frequent measure. Given this, in discussion with the CS manager and the researcher, it was established that this KPI should have a frequency of measure on a bi-annually basis and measures are recorded from the beginning of the year 2014 onwards. With this input, an average was then calculated per half year and a final number was made known. Figure 14 provides the reader with the perceived relation KPI definition template, where one can find all information regarding the KPI. Target, lower and middle bound was discussed with the CS manager and the researcher.

4.3.2.2 Implementing Wallet Share KPI

To complement the identification of performance levels for the category of customer value, the KPI of wallet share is developed. Wallet share is the percentage of a specific customer's spending for a type of good or service that goes to a particular company. Translating for the case company, wallet share is the percentage of the customer's spending for mechanics that goes to VDL ETG. This allows a greater understanding of the amount of business that VDL ETG acquires from specific customers and identifies where to allocate resources to obtain a higher share of wallet.

PERCEIVED RELATION	
Description	Assessing perceived customer relation towards VDL ETG
Target	4
Report Periodicity	Bi-annually
Unit of Measure	Scale (1-4)
Formula	Manager of sales department perceived relation.
Lower & Middle Bound	L: 1 M: 2
Owner	Jeroen Boekema
Data Source	file:///\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\Margin Report ETG + Wallet Share.xlsm

Figure 14: Perceived Relation KPI Definition Template

WALLET SHARE	
Description	How much of the customer's wallet is being spent at VDL ETG. (Mechanics market)
Target	1%
Report Periodicity	Bi-annually
Unit of Measure	%
Formula	Turnover/Total Spent by Customer
Lower & Middle Bound	L: 0,6% M: 0,8%
Owner	Jeroen Boekema
Data Source	file:///\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\Margin Report ETG + Wallet Share.xlsm

Figure 15: Wallet Share KPI Definition Template

One needs to take into account that many companies have certain strategies of not spending more than 5% of total in only one supplier (to avoid risks) so, for obvious reasons, this must be taken into account when discussing further actions to gain more wallet share in a specific customer.

To calculate the percentage of wallet share, data regarding turnover made for the top nine customers was easily extracted from the business intelligence platforms. On the other hand, to determine the

total amount spent per each of those nine customers in mechanics was challenging. To do this, input about the percentage spent by each of the nine customers on mechanics was gathered from all the account managers of those customers. This information is highly confidential and not easy to obtain, but after eight weeks, all data was finally made available. All it took from this point onwards was to calculate the percentage wallet share per customer and then making an overall average to arrive at a final value. Likewise the perceived relation KPI, it does not make much sense in measuring this KPI on a very frequent basis, so taking this into account, the report periodicity was established also on a bi-annually basis. Moreover, target, lower and middle bound are also determined by the CS manager. **Error! Reference source not found.** gives insight towards this KPI's information.

4.3.2.3 Implementing Dual Sourced KPI

To fill in the gap of the flexibility category, the proposed KPI to implement is the percentage of dual sourced products in total production of PARTS. To do so, the reader should have some knowledge as to how production works at VDL ETG to fully understand this KPI. This is explained next.

4.3.2.3.1 Product/Item Categories and Item Groups

All products/items that make up the modules that VDL ETG sells are either made at VDL ETG or bought from VDL ETG's suppliers. These products/items are given a category, and consequently, an item group. Figure 16 provides an overview of this information. PARTS production categories go from one to three and each category can have two types of item groups (regarding mechanics work or sheet metal work). Category one is fixed in terms of sourcing, products/items can only be produced at VDL ETG. This can be due to intellectual property matters or due to customer requirements. On the contrary, products/items with categories two or three can be produced inside or out (produced at VDL ETG or bought from a supplier). Hence, it represents the flexible products.

Sourcing	Category	Item Group	Description
Fixed In	1	100	Mechanics
		105	Sheet Metal
In/Out	2	200	Mechanics
		205	Sheet Metal
In/Out	3	300	Mechanics
		305	Sheet Metal

Figure 16: PARTS Production Categories and Item Groups

The differences between categories two and three are concerning complexity of the products/items, where category two products/items are relatively simple and category three products/items are highly complex. It is easier to switch from sourcing inside to out, or vice-versa, a product/item from category two given that it does not involve exchanging and/or transferring the production know-how but only the technical production documents (drawings). Whereas, to switch a category three product/item, this know-how must be transmitted, making it a complicated process. For VDL ETG, the main focus is producing category three products/items since these are the ones related to the core competences of the company and bring the differentiation factor. Additionally, the higher the complexity of a product/item, the more money can be made from them.

These decisions of producing in or out are called the Make-Buy decisions and they are made by a team made up of a manufacturing engineer, SCE, cost engineer, a buyer and a production engineer. Decisions to make or buy are established mainly based on the workload of the factory. If VDL ETG is on a high turn, this means that there is a lot of production going on so Make-Buy decisions are probably translated into buying due to the inexistence of capacity at the factory. In this case, the first products/items to be bought are from category two, and when it is absolutely necessary, category three starts being bought too. Furthermore, if the factory is on a low turn, where there is not a lot of production going on, Make-Buy decisions favor the make, to fill up the capacity of the factory.

Now the reader should have enough understanding about the Make-Buy decisions at VDL ETG so the KPI implementation can now be described.

4.3.2.3.2 Make-Buy Model

To assist the implementation of this KPI, a Make-Buy model was made. The objective of the model is to provide a clear overview of ramp-up/down flexibility at PARTS and serve as a tool for dynamic Make-Buy decisions according to factory load. It aims to measure the KPI percentage of dual sourced products/items in PARTS production (in terms of turnover). The KPI has two PIs associated to it, and they are the following: PI 1 - percentage of category two and three products/items in total production (in terms of turnover) and PI 2 - percentage of dual sourced capacity in categories two and three (in terms of turnover). This is schematically represented in Figure 17. PI 1 represents the theoretical flexibility whereas PI 2 measures the products/items that are ready to be made or bought from the total flexible products/items. PI 2 should ideally be equal to 100% since they represent the flexible products/items, but for these to be realistically flexible, they must be ready to be dual sourced.

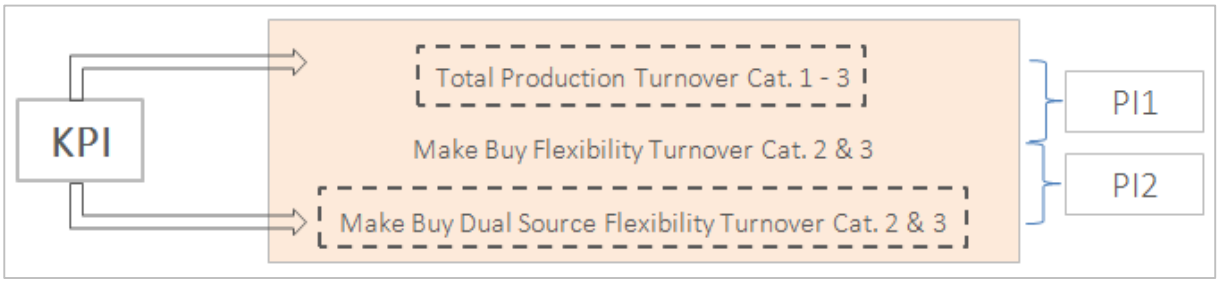

Figure 17: Dual Sourced KPI and PIs

For a product/item to be considered dual sourced, it must have a supplier associated to it (if it's originally a make product/item) or an internal production routing(s) (if it's originally a buy product/item). This signifies that it is ready to be made or bought. Data is extracted from the business intelligence platform (iQBS) where information is updated every night. For all the make products/items, the data source of "planned inventory movements" was analyzed and it was assessed whether each product/item had a supplier associated to it. If yes, the dual sourced turnover of that product/item was calculated by multiplying the quantity by the standard cost price. For all the buy products/items, purchasing "planned orders" was considered and the existence of a production routing in each product/item was assessed. If this were true, the dual sourced turnover was calculated by multiplying the order quantity by the price per item.

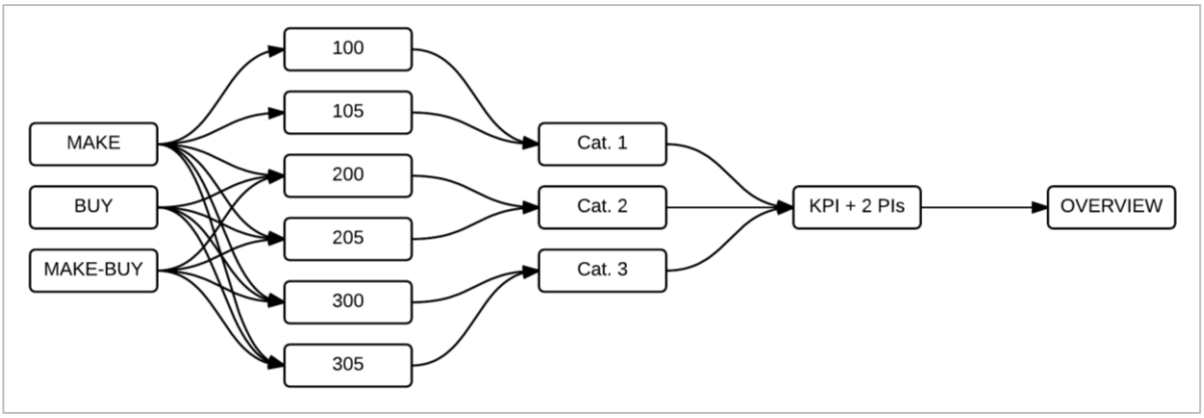

Figure 18: Make-Buy Model Structure

Figure 18 provides the clear structure of the Make-Buy model. All item groups are analyzed individually, where the item groups 100 and 105 only have the make products/items associated to them since they are fixed and can only be produced within the case company. All other item groups have a make, a buy, and a make-buy information. This data is then consolidated into the corresponding categories, which then provide the necessary data to be extracted from the KPI and the two PIs sheet to arrive at the final percentages. An overview is then made to centralize all information. As one can see from the structure, this model offers all kind of analysis possibilities and in different depths of detail (item group level or category level).

Figure 19 represents the worksheet of item group 200 regarding make products/items. The figure serves as example of the templates and layout of each worksheet (concerning item groups and categories). All worksheets have a title, referring to their item group or category and identification is made as to what kind of information is presented (make, buy or make-buy). Data is presented in the form of four periods of 13 weeks each. This distinction is made because of data accuracy issues. Since this is a forecast KPI, data accuracy can be questionable when one looks in the far future. Periods three and four lack a lot of input so the main focus of this model is towards periods one and two which represent the high data accuracy and therefore, the better forecast.

For each 13 week period, information regarding if it is a make, buy or make-buy product/item is available, as well as the year, week, ISO start week, turnover and dual sourced turnover data. Under each period, a graph is provided to compare turnover with the dual sourced turnover.

An overall graph is then made available, where it merges all four periods into one for users to have access to an integral view of that item group or category over the four periods. Lastly, a small overview table is visible, where the total turnover and total dual sourced turnover is calculated corresponding to all the four periods and for observation purposes only, the percentage of the dual sourced turnover in the total turnover is calculated too.

As mentioned before, Figure 19 is an example of the template present in all worksheets in this model (except for the overview) where all information is gathered in this way. The categories' worksheets are simply a consolidation of the corresponding item groups and offer the overall view which will be the basis for the calculation of the KPI and the two PIs. Arriving at the KPI and PIs is described next.

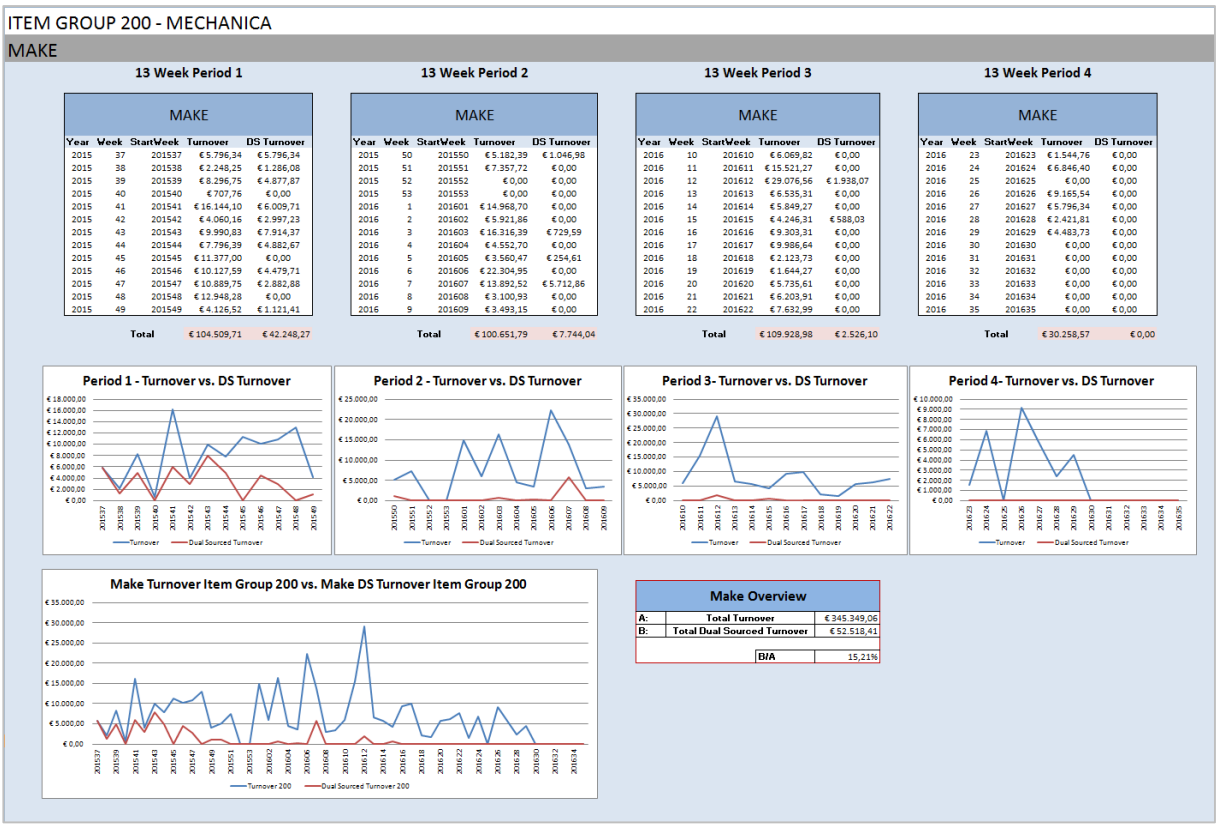

Figure 19: Item Group 200 Make Data

4.3.2.3.3 KPI and PIs

To better understand the KPI calculation, Figure 20 provides a simple view of all the information made available. There is a consolidation of the entire make, the entire buy, and the entire make-buy products/items and the corresponding turnover and dual sourced turnover is made available. Then, there is a consolidation of products/items belonging to categories two and three, and their corresponding total turnover and dual sourced turnover. To finally calculate the KPI (percentage of dual sourced products in total production turnover) one must divide the total dual sourced turnover from categories two and three (red cell) by the total internal production turnover (green cell).

Figure 21 serves as a simple view to understand how PI1 (percentage of theoretical flexibility in production turnover) was derived. It is a very simple calculation, where the total make-buy turnover of categories two and three (red cell) must be divided by the total make-buy production turnover of categories one, two and three (green cell).

Category	Product/Item Type	Turnover	
1+2+3	Make	Total	DS
1+2+3	Buy	Total	DS
1+2+3	Make-Buy	Total	DS
2+3	Make	Total	DS
2+3	Buy	Total	DS
2+3	Make-Buy	Total	DS

Figure 20: KPI Calculation

Category	Product/Item Type	Turnover	
1+2+3	Make	Total	DS
1+2+3	Buy	Total	DS
1+2+3	Make-Buy	Total	DS
2+3	Make	Total	DS
2+3	Buy	Total	DS
2+3	Make-Buy	Total	DS

Figure 21: PI 1 Calculation

Category	Product/Item Type	Turnover	
1+2+3	Make	Total	DS
1+2+3	Buy	Total	DS
1+2+3	Make-Buy	Total	DS
2+3	Make	Total	DS
2+3	Buy	Total	DS
2+3	Make-Buy	Total	DS

Figure 22: PI 2 Calculation

Lastly, to calculate PI 2 (the dual sourced flexibility of categories two and three), Figure 22 provides the overview. Total make-buy dual sourced turnover from categories two and three (red cell) must be divided by the total make-buy turnover of those two categories (green cell).

4.3.2.3.4 Overview

The overview worksheet is made to provide the summary of the model and the conclusions drawn. First, information about this KPI is combined in Figure 23 where the target, middle and lower bound are determined by the manager of PARTS and the report periodicity was set to a monthly basis.

A clear distinction between total make and total buy products/items turnover and dual sourced turnover can be found in the overview worksheet. Figure 24 is a screen shot of one of the elements in the overview which show this comparison. Total make turnover vs. total make dual sourced turnover is graphically presented and the same analyses for buy is made and presented graphically as well.

DUAL SOURCED PRODUCTS

Description	Assessing internal flexibility of PARTS by determining the % of dual sourced products in total production turnover.
Target	30%
Report Periodicity	Monthly
Unit of Measure	%
Formula	(Cat. 2 & 3 dual sourced products/ Production turnover from Cat. 1,2 & 3)*100%
Lower & Middle Bound	L: 10% M: 20%
Owner	Michael van Vugt
Data Source	file:///\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\Dynamic Make Buy KPI.xlsm

Figure 23: Dual Sourced Products KPI Definition Template

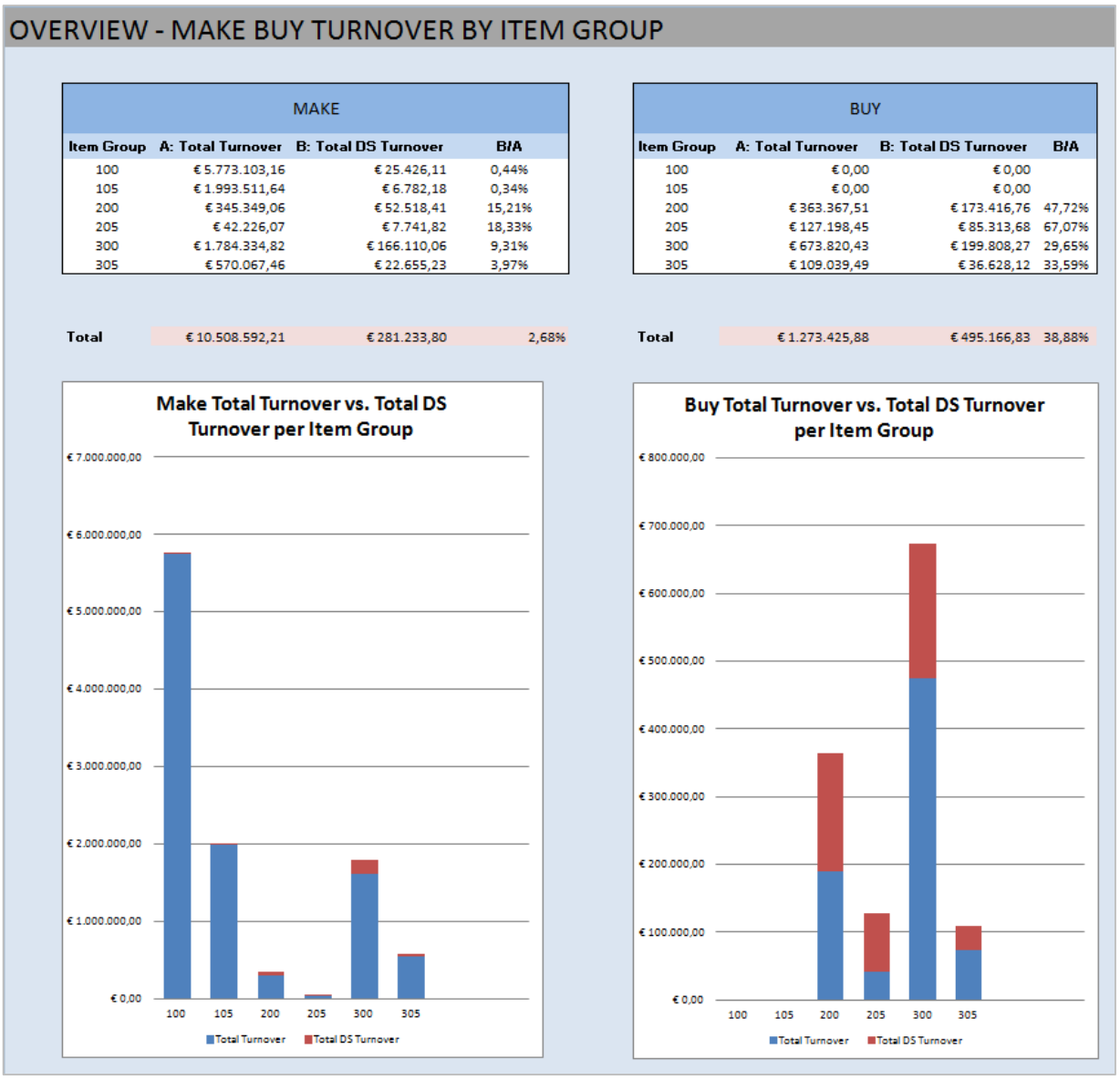

Figure 24: Overview of Make-Buy Model

This overview was made taking into account the desired views that the manager of PARTS wished to have. With this simple comparison between the make and the buy products/items, it is easy to identify what needs to be changed. As one can easily identify from the Figure 24, the make dual source flexibility (2.68%) is extremely low compared to the buy dual source flexibility (38.88%). This means that most products/items considered 'make' do not have suppliers associated to them. Purchasing department should then work in collaboration with PARTS to assign the correct suppliers to these products/items so that they can be considered dual sourced and provide higher levels of flexibility. On the other hand, to increase flexibility of the 'buy' products/items, PARTS planners should create production routings for these products/items so that when VDL ETG is facing a low turn, instead of buying, they can be flexible enough to produce in-house and vice-versa when confronted with a high turn.

An additional analysis of flexibility was made regarding flexibility of each machine, responding to PARTS' manager requirement as a complement analysis to flexibility. All machines were analyzed as

to what product/item category they had assigned to, to ultimately check if there were cases where there were machines only producing category 1. This case scenario is to avoid as much as possible to fight the low turns.

4.4 Chapter Conclusion

This data collection, analysis and interpretation chapter has mentioned the AS-IS situation regarding SCP measurement at VDL ETG in terms of what KPIs are currently being applied. The TO-BE and ideal SCPMeS framework was proposed, derived from theory and discussions between the researcher and the key stakeholders. This represents the ideal situation. Once comparing both AS-IS with the TO-BE, the gaps were identified. These are two large gaps in the AS-IS KPIs in use at the case company: no specific KPIs to identify performance levels on the categories of customer value and flexibility. It is important to notice that these gaps are identified when one is using the performance pyramid, derived from literature review and considered the chosen SCPMeS framework. An attempt to close these gaps is developed by the implementation of three new KPIs; relation and wallet share to fill the gap of customer value and dual sourced products to close the flexibility gap. Implementation procedure of these KPIs was described, taking into account management team (MT) members requirements.

Not much time has passed since implementation of these KPIs occurred, making it difficult to drawn any immediate conclusions in terms of the implementation *per se*. Nevertheless, after a few weeks of being implanted (6-7 weeks), the dual sourced products KPI has worked perfectly and is being measured on a weekly basis but reported on a monthly basis. On the other hand, future work regarding the establishments of questionnaires to measure trust of VDL ETG's customers towards the company is a must. Once this requirement has been fulfilled, the relation KPI can be implemented with more accurate information to provide a number for performance levels of the category of customer value. Regarding the wallet share KPI, since the report periodicity of this KPI is bi-annually, just like relation, CS manager (the owner of this KPI) should be aware that the manual input of this KPI (the total spent per customer) should be updated every six months. It is impossible to automate this KPI to the fullest since this manual input is regarding confidential information on the customers' behalf. Account managers are the ones who have access to this data and must provide it to the CS manager for consolidation.

Until now and considering the proposed SCPMS shown in Figure 4, the TO-BE SC vision has been identified, and from the vision, the main goals can be identified. These goals are maximizing customer value at the lowest total cost. The case company's key success factors have been pointed out and with all of this, step 1 of the SCPMS framework is completed. Step 2 is also complete since the AS-IS situation has been described, likewise the TO-BE scenario and the GAPS between these two. Step 3, the action plan, will be defined in the next chapter where the design for implementation description takes place. This will give way for step 4, the performance measurement step of the chosen SCPMS framework to take place.

5 Design for Implementation

This chapter represents the design for implementation (block 7 of the research framework, represented in Figure 2. As already stated in Chapter 1 section 1.5.1.2, this phase is the second key element of the research and consists of the RADAR logic currently in place by the EFQM on continuous cycle improvement. The RADAR logic is made up of four divisions: Results Target, Approach, Deploy, and Assess & Refine. The action plan to enable the design for implementation of the SCPMMSs at VDL ETG is described here, in an attempt to answer the fourth research question and ultimately answer the research problem statement.

The researcher, together with MT members and the company's thesis supervisor, came to the conclusion that, given the time frame of this research (8 months), the design for implementation will cover the internal SCPMeS. Once this is accomplished, implementation of this system may proceed to them be incorporated into the chosen SCPMS (derived in Chapter 2).

5.1 Results Target

This section answers dissertation research question 4(a) and it is represented as block 7.1 of the research framework demonstrated in Figure 2. It is the starting point for the design for implementation milestone in this dissertation. The following sub-questions are answered:

1. What is the deliverable expected from the design for implementation?
2. What are the desired characteristics of the deliverable?
3. Who should be the owner of the deliverable and what is the preferred outcome?

Innumerous meetings with MT members were established in order to identify their needs towards the design for implementation of the SCPMeS. The main conclusions drawn are as follows:

- MT members acknowledge the need for a clear communication tool that will serve as a facilitator of decision-making on a high level. To do this, an overall view of the high level KPIs should be provided where they can clearly identify how the company is performing.
- Such a tool that will be used in MT meetings with all MT members and the general director, so it must be extremely clear and contain an integral view.
- MT members expect to have insight on current information regarding the most recent data, but also find it imperative to have a comparison with historical data so that trends can be identified.
- It should be a flexible tool so that any change that may happen (for example: if MT members feel the need to add a high level KPI) can be easily implemented.
- MT members require an automated tool so they can focus on their day-to-day activities and not have to waste time updating this integral decision-making tool once a month.
- Definitions are important, so that everyone knows what is being talked about and this was a great issue shown by the MT member during discussions. To make sure that everyone is on the same page as to what data is being presented is key.
- Data accuracy was also a key point, so making sure that the extracted data is exactly what is needed is a must.

So taking into account the seven requirements presented by the MT members, the expected deliverable from the design for implementation is a communication tool that will facilitate MT member to make better decisions by providing an integral overview of how VDL ETG is performing and what really needs to be improved or receive a bigger focus.

It is believed by the researcher and key stakeholders that the owner of this deliverable is the general director of the case company. He will be the end customer of the deliverable but the MT member in charge of maintaining the communication tool should be the TQ manager. In case there is anything needed to be changed, for whatever reason, the person responsible for this alteration is this MT member.

5.2 Approach

Once the expected results from the design for implementation are made known, the next phase is introduced. This second stage of the RADAR logic answers research question 4(b) by identifying the chosen approach for the successful design for implementation. It is represented by block 7.2 on the research framework. The following sub-questions are answered:

1. What is the approach?
2. How will it attend to all the requirements described in the previous section?

After carefully analyzing all seven requirements exposed by the MT members and consolidating all the knowledge and information gathered and recognized up to this point of the research, an approach was developed. This approach aspires to respond to all these requirements and serves as the enabler to successfully attempt to answer the problem statement. The approach is described next, where a clear explanation as to how it will individually overcome the requirements is presented.

5.2.1 Clear Communication Tool for Decision Making Process

To respond to requirements regarding the need of a communication tool to support the decision making process, the approach is the establishment of a KPI dashboard with the chosen SCPMeS. This means that once MT members have their monthly meetings with the general director and must report on how their department is performing, they no longer need to do this separately with their own dashboards where the KPIs in place are listed and their status is identified. With the new dashboard, these meetings can occur with only one dashboard where an overall view is provided. This will be on a high level, since it is a requirement, so not all KPIs currently in place are included, just the ones derived from the final SCPMeS.

5.2.2 Overall View of Case Company's Performance

To make it a clear and visual dashboard, the categories that make up the pyramid should change according to their performance status. Their performance status will depend on the performance of the KPIs that make up each category. Since there may be some KPIs within a category that are more important than others (as to enabling the user to identify how the category is performing), there should be a weight factor given to each KPI which will then allow a more realistic overall status of the category. There should also be an overall speedometer to check the performance of the pyramid as a whole. So assessing how many categories are with a bad performance against

the ones with a satisfactory and good performance to reach a final number that can classify the case company's performance. This provides the integral view of the company, one of the requirements from MT members.

5.2.3 High Level KPIs with Additional Information on Demand

The main aim of the dashboard is to provide the high level, integral view of the company's performance but the model should also be able to provide a one-step-deeper analysis to back up the high level view. This means that if a category in the performance pyramid is performing badly, and the MT members want to focus on that category, the model should have information regarding why that specific category is performing badly. Data concerning which KPIs are within that category and their individual performance is important, together with all additional information needed.

5.2.4 Historical vs. Current Data

The interest revealed by MT members for the dashboard to provide a clear historical data view makes it crucial to incorporate this feature in the deliverable. To offer this, the previous month or week information should be exposed, together with the AS-IS information, permitting the users to compare both pyramids and clearly spot what has changed over time and where attention should be directed.

5.2.5 KPI Library

To grant the end users of the deliverable insight on what KPIs will be analyzed, a clear KPI library should be provided. This standardizes the information available of all KPIs and makes users aware of what is really being examined.

5.2.6 Automation

Regarding the automated required characteristic for the deliverable, in order to have such feature, one must treat data accordingly. This means that all data that should be extracted for the dashboard must be made available for all MT members, and for it to be automatically updated, it must be prepared for this. This presents itself as a real challenge since each department measures their own KPIs where data is extracted from MT members' personal files. This also means that there is no standard structure for these documents, making it difficult to automate.

5.2.7 Flexible

The flexibility factor can be incorporated into the dashboard by constructing it in such a way that if at any time an MT member decides to include one more KPI to a certain category, it is a feasible scenario. Just like when the action is to remove a KPI or probably even change a category's name. These are all features that should be included in the dashboard if one wants to provide the best design for implementation.

5.2.8 Data Accuracy

Fighting the battle for data accuracy is challenging. All data should be extracted from the MT members' personal files where they track information regarding the KPIs that are in the final SCPMeS. Naturally, these files are connected to external sources of information, for example, the case company's business intelligence platform that is updated every night. This means that, if MT

members have their documents linked to this daily updated information, data accuracy should not be a problem. On the other hand, if this is not the reality, actions should be taken to make all data extraction connected to the business intelligence platforms and make data extraction an automated process.

Now that the reader is aware of what the approach is, the next stage of the RADAR logic is to make clear as to how the approach is deployed. This is described next.

5.3 Deploy

The third step of the RADAR logic is “deploy” and this is identified by block 7.3 of the research framework and aims to answer research question 4(c) by explaining the approach deployment procedure.

1. What is the structure of the dashboard?
2. What elements make up the main view?
3. How was the dashboard developed?

5.3.1 Model Structure

To start off the deployment process of the approach, one must identifying its structure to then have enough insight for the deployment *per se*. Figure 25 provides the reader with a simple schematic diagram of the model’s structure and all the different worksheets that make up the deliverable. Data is extracted from the business intelligent platform (iQBS) to make up all the MT members’ individual department dashboards. These documents will then serve as the database for all the information extracted to the categories’ individual worksheets, which are considered supporting data for the dashboard. Naturally, these worksheets are providing the information regarding performance levels for each category of the SCPMeS hence being linked to the dashboard *per se*. Moreover, the categories’ individual worksheets are also making all information regarding the KPIs available in the KPI library. Last, the explanation worksheet serves as a guide for the user. Data is exchanged between this worksheet and the dashboard’s worksheet where further explanation is provided in sections 5.3.1.2.1 and 5.3.2.10.

5.3.1.1 Main View

As mentioned above, the approach is the development of a KPI dashboard incorporating the chosen SCPMeS with the high level KPIs, providing an integral view of the company’s performance and a clear communication tool to facilitate decision making processes for MT members. To accomplish this, one should start by planning what the main view of the dashboard should look like and what type of information is necessary to offer de sufficient data for MT members during their monthly/quarterly meetings with VDL ETG’s general director.

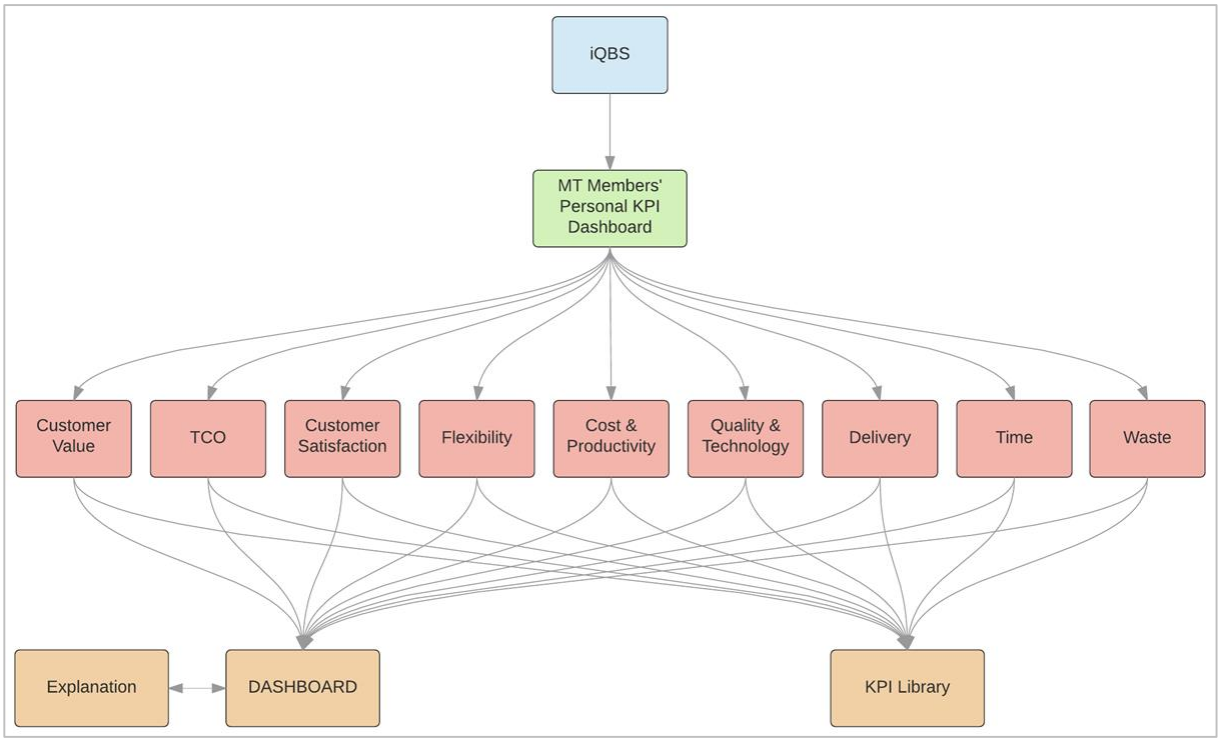

Figure 25: Model Structure & Information Connections

5.3.1.1.1 Ranking Procedure

For obvious reasons, the performance pyramid will be the spot light of the dashboard, where only the categories' names are visible and their fill is according to the KPIs' status. To establish the color ranking, discussions with MT members took place to analyze what rankings were currently in place at the case company. The findings were as follows: there is a target, a lower and middle bound for each KPI and rankings (color and number) are based on this. Figure 26 is a representation of this. If a KPI's performance is equal or above target, it is given a green color and a score equal to 4. If the performance is equal to the middle bound or better, but below target, it is given a yellow color and a score of 3. If the performance of the KPI is between the lower and middle bound, it is represented by the orange color and score equal to 2, and lastly, if the performance is equal to the lower bound or it is performing below it, is has a red color and a score of 1.

5.3.1.1.2 Speedometer

This ranking procedure will be maintained so MT members feel somewhat familiarized with the scoring of the performance and can easily and quickly relate to it. Once this ranking is established, the categories that make up the performance pyramid will be filled with either the color red, orange, yellow or green, according to their performance status. Since the categories can take up to 4 different scenarios, it is interesting to include, in the dashboard's main view, a table indicating how many categories are in the green category, yellow, orange and red. This table will then supply the information necessary to construct a speedometer. This speedometer should provide a final number that indicates the performance of VDL ETG as a whole. It ought to be included in the main view of the dashboard, where the result number is between 0 and 4 (0 being minimum score and 4 maximum) and the result is the weighted average of how many categories are in each color.

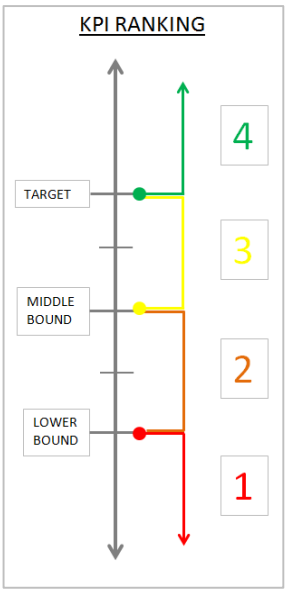

Figure 26: KPI ranking procedure

5.3.1.1.3 Update Process & Historic Comparison

One of the essential features to include in the dashboard view is a button that updates the information, as well as a button that provides users to compare historic data with current one. These will also be part of the dashboard's core view.

5.3.1.1.4 Data Availability

An indicator of the percentage of data available must be a included in the dashboard's view since gathering all data from different external sources (MT members' personal files, business intelligence platform) and consolidating it into one document will not be easy. A new folder where only MT members have access to it must be created under the TQM domain and permissions will need to be issued for the researcher to have access to those personal files and data, so they can be extracted. This takes more time than one can plan so having this indicator of the data available is a must for the initial phase of the dashboard.

5.3.1.2 Supporting Data

Having identified the key elements that make up the dashboard's main view, the supporting data will now be described.

5.3.1.2.1 Explanation Sheet

It is imperative to have an explanation sheet concerning how the dashboard works. All assumptions that will take place must be described and explained here, as well as a brief description of the performance pyramid and what KPIs are within each category.

5.3.1.2.2 KPI Library

Fulfilling one of the requirements presented by MT members, a KPI Library is a must. This should provide a concentration of all KPI information, using the template mentioned previously in this research. This guarantees that once definitions are made and incorporated into a document, when MT members are discussing these KPIs, they will be discussing about the same things. Confusions are avoided and everyone is on the same track.

5.3.1.2.1 Categories' Sheets

This will be the main supporting data for the dashboard. When dashboard users are faced with a red category within the performance pyramid and want to go one step deeper as to understanding what went wrong, that category's worksheet will provide this. All categories' worksheets should include all KPIs within that category, as well as all data regarding them. The data in these worksheets will be linked to the performance pyramid in the main view of the dashboard to provide the right status color.

5.3.2 Dashboard Construction

The structure of the dashboard has been introduced and now the construction of the dashboard is described. The dashboard was developed in the software Microsoft Excel since it is available at the case company and all information about KPIs are in this form.

5.3.2.1 Step 1 – Build Category Worksheets

The first step to construct the dashboard is to start off by creating the worksheets for all categories of the performance pyramid. This step is entirely based on the SCPMeS and what KPIs belong to each category. The worksheets must include the category name, date, table with all KPIs that belong to that category and their data, the KPI template with definition, targets, owner, etc., weight factor table, and graphs with KPI performance against target. Figure 27 is the structure of the Customer Value category worksheet. The two KPIs (perceived relation and wallet share) are clearly identified in the main table. Inputs regarding the weights of each KPI, their owner, target, middle and lower bound, actual performance, difference between the actual performance and the target, and status are now ready to be filled in. Bellow this main table, the status ranking is depicted and the pyramid input is line is constructed. The column regarding the most recent information is the one most to the right, so the data that will be extracted from this worksheet to the pyramid will be from the pyramid input line and from this column (this is represented in Figure 27 by the purple box).

The weight factor table is also present, where it was constructed based on the ratio method from appendix F (procedures for determining the weights of selection factors in the weighted matrix delivery decision approach – tier 2) from the TCRP report 131 (A guide book for the evaluation of project delivery methods – transit cooperative research program – transportation research board of the national academies). This method was chosen based on its simplicity and user friendliness. Input for this table should be provided by the general director since he should be the one to identify the most important KPIs for each category. The weight factor table works in the following way: the user should first rank all the KPIs according to their importance for that category and then give weights to each KPI based on its rank. The lowest ranked KPI will be given a weight of 10. The weight of the rest of the KPIs should be assigned as multiples of 10 (for example: KPI 1 is ranked as 1 and KPI 2 is ranked as 2, lowest ranked is KPI 2 so it will have a weighting of 10, and, if KPI 1 has a weight of 30, it means that KPI 1 is 3 times more important than KPI 2). The last step is normalizing these raw weights (back to the example: normalizing KPI 1 would be the weighting of KPI 1 divided by the sum of all weightings).

A simple text box with the message – if you want to make alterations to the KPIs' weights, please go to "Explanation" where you will find the instructions – is located bellow the weight factor table and a

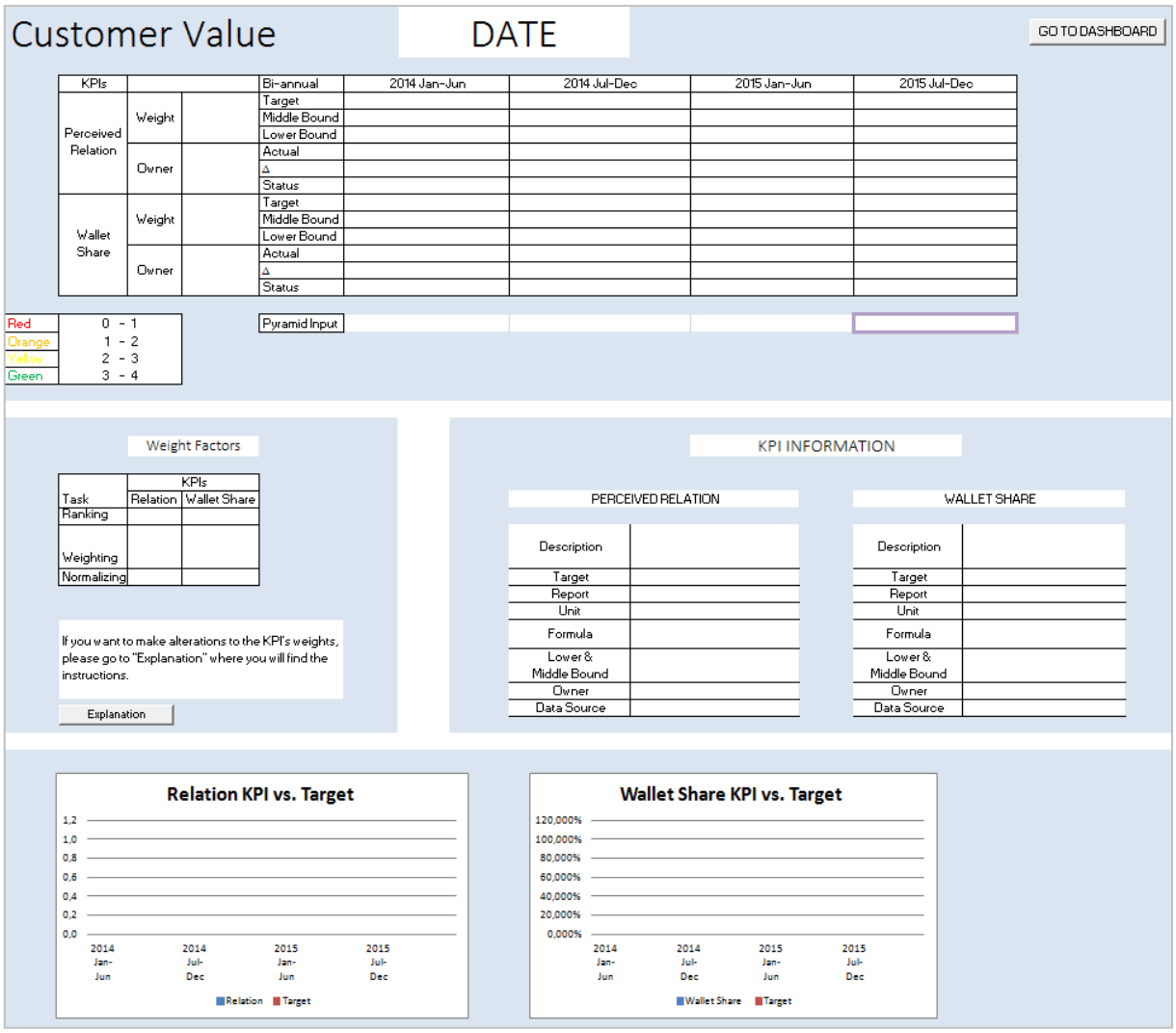

Figure 27: Customer Value Worksheet Structure

button is added to direct the user to the explanation worksheet, in case needed. Templates regarding KPI information are present in the assigned section, where users can easily encounter, in case needed, with all data for a certain KPI. At the end of this worksheet, the graphs are visible, where users may compare the actual performance against the target.

To sum up, the manual input required in this worksheet is the following:

- Main KPI table
  - A one-time manual input to provide cells with the source of data for KPI target, middle and lower bound, and actual performance.
- Weight factors table
  - All rankings and weightings.
- KPI Information templates
  - All data in manual input.

The automatic cells are the following:

- Main KPI table
  - Weight information is extracted from weight factor table in the worksheet.

- Owner information is extracted from the KPI template in the worksheet.
- Difference between actual performance and target are automatic, since they have a formula built in that makes this calculation.
- Status is also automatic because it has a built in formula that calculates how the actual performance ranks according to the target, lower and middle bound of that KPI. The corresponding color of the ranking will appear based on the status.
- Pyramid input is automatic, where it has a built in formula that takes into account the status of the KPI and its weight factor to arrive at a final value.

| Weight factors table

- Normalizing information is automatic. The calculation method has been described in the previous paragraphs.

| All graphs' data is linked to the main KPI table (target and actual performance).

A button named "GO TO DASHBOARD" is placed at the top right hand corner of the worksheet to facilitate user interaction with the dashboard, and once clicked, it directs user to the dashboard sheet. All of the above information explains to the reader the structure of the Customer Value worksheet, serving as an example for all other categories. The only difference from the other categories will be in the KPIs, number of KPIs, weight factors, the periodicity of measure can be in months or weeks (whereas in this example its bi-annually), and the KPI information.

5.3.2.2 Step 2 - Filling the Categories' Worksheets with Available Data

This step can be a real challenge when the data needed to be extracted is not in the correct extraction form. This means that the information has to be treated to then be automatically extracted to this worksheet. As stated before, this step requires the granting of permissions for the researcher to gain access to certain personal files. All permission requests were sent to the corresponding MT members, who would evaluate if they accepted to give permission or not. If yes, they would then send the IT change request to the IT helpdesk, who would perform this change. Taking into account that whilst this stage was in development, it was summer holidays season, which slowed this entire process, taking up to one month to get just one permission. In case the MT members were not willing to share their information, data was not made available.

After treating the available information to the point where it can easily be extracted automatically from the source document, formulas should be introduced to the correct cells indicating this path. Regarding the new implemented KPIs, all data to identify their performance was collected, treated and saved in the same file as the dashboard document, offering permission for all MT members to have access to it. All data that is not yet available is depicted with blue cells so users can easily identify what is actual data and what is not. Figure 28 is an example of how unavailable data is depicted by the blue cells. The data in the blue cells are estimated values that were included to make sure the dashboard was working.

Additionally, when data is still not available from the present month (because information is only consolidated at the end of the month, or for any other reason) the model will use the most recent available information to come up with the final status of the category. This is also shown in Figure 28

where data regarding the KPI for customer complaints is not available for the most recent month (September) so the overall performance value for the category of quality & technology will be calculated based on the previous month performance of the customer complaints KPI and the current month's performance for technology roadmap KPI. Information regarding the target, lower and middle bound for the KPI technology roadmap and the data source is also missing.

Appendixes 1 to 8 depict the remaining categories' worksheets with the available information filled in and all unavailable data in blue cells. With this information, the performance pyramid can now be constructed for the dashboard's main view. The KPI definition templates for all KPIs are described later in this chapter, as well as data analyses. This section serves only to make the reader aware that data should be filled in to then proceed to the next step: constructing the performance pyramid.

5.3.2.3 Step 3 - Performance Pyramid Construction

Now that all categories' worksheets are ready with the available information filled in, the performance pyramid can be constructed for the dashboard's main view. This is a relatively easy step where the

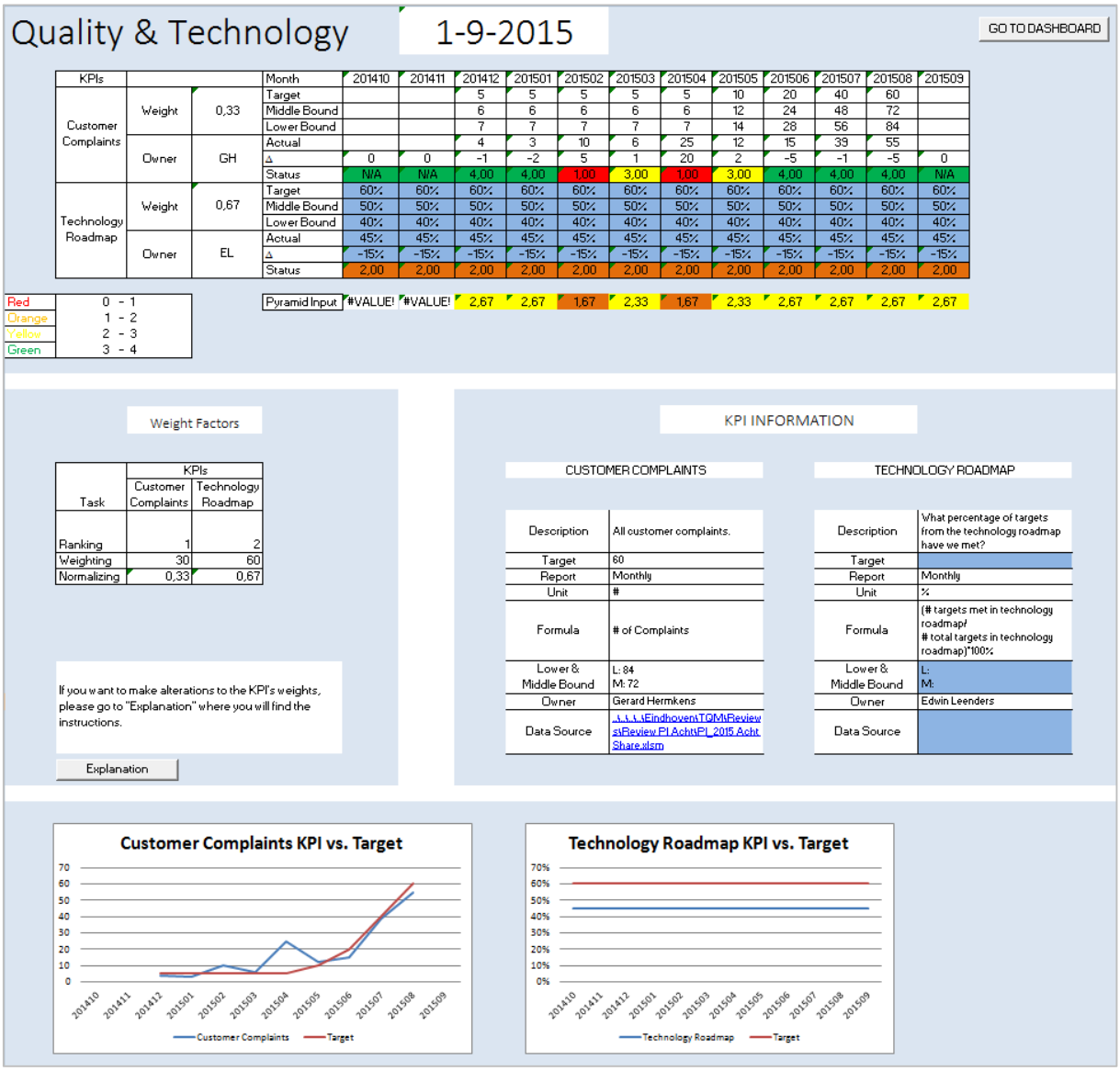

Figure 28: Example of Data Not Available

pyramid should be built with all the categories and the internal SC vision. Once the pyramid's structure is set, the next step is to extract the statuses of each category and filling the corresponding category with the status color, creating a strong visual impact on the performance levels.

5.3.2.4 Step 4 - Extracting Category Status to Pyramid

For one to successfully establish an automated way to extract the required information about each category to the performance pyramid (dashboard's main view), the safest procedure is using Excel Visual Basic for Applications. In view of this, a macro was developed to update the pyramid with the necessary information. The code of this macro is made available in Appendix 9 under the name of Macro 1.

This macro is called Update_Pyramid_Colour and it is divided into four sections. The first section is responsible for opening all the data sources and closing them so information can be updated to the dashboard secondary data worksheets. Section two is responsible for assigning the correct category color fill to the performance pyramid according to its status. Section three allows the table with the number of categories per color to be constructed (information for the speedometer later explained) and lastly, section four finalizes the macro by directing the user to the dashboard sheet and a popup message box appears stating that the pyramid is up to date. To trigger this macro, a button needs to be created and added to the dashboard's main view where users can easily have access to it whenever they wish to see the most up to date information and status of performance. Figure 29 provides an example of the performance pyramid after running the macro.

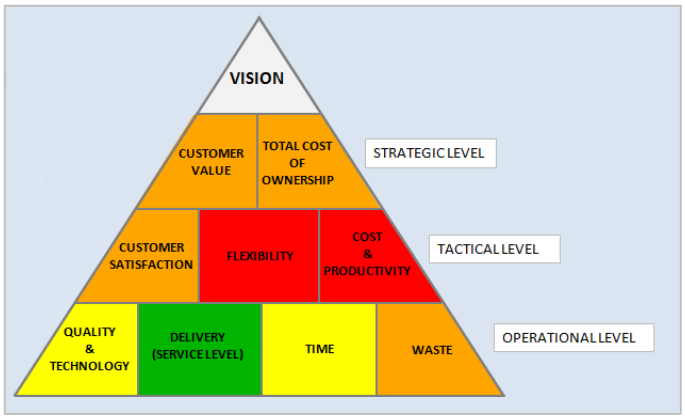

Figure 29: Performance Pyramid

5.3.2.5 Step 5 – Build Speedometer

To construct the speedometer, a doughnut diagram was made together with a pie chart (pie chart in front of doughnut). Only half of both graphs are visible and the doughnut chart represents the ranking range, going from red to green with orange and yellow in between. The pie chart is the dial pointer that indicates the current value of the case company's performance.

Figure 30 shows the speedometer information, where it contains two tables of data – the one on the left hand side is regarding to the doughnut data (speedometer data) and the one to the right hand side is the pie chart information (pointer data). Focusing on the pointer data, the category average is calculated with a weight average based on the number of categories per color.

The source of this data is the table located in the dashboard's main view with the number of categories per color. Red category has a weight of one, orange of two, yellow of three and green of four. From Figure 30, the category average is 2.22 which corresponds to 55.56% of the maximum score (4). Transforming these values into the pie chart, the pointer value will be 55.56% of the total visible speedometer are (160) which is 88.89. With a pointer width of 3, the total blank are will be the total speedometer area (320) minus the sum of the pointer value (88.89) with the pointer width (3). Figure 31 provides the final result with the dashboard's speedometer and the current company's performance value within the range.

SPEEDOMETER DATA

Speedometer Data		Series Level
Starting Point	0	0
Red Range-1	10	10
Red Range-2	10	20
Red Range-3	10	30
Red Range-4	10	40
Orange Range-1	10	50
Orange Range-2	10	60
Orange Range-3	10	70
Orange Range-4	10	80
Yellow Range-1	10	90
Yellow Range-2	10	100
Yellow Range-3	10	110
Yellow Range-4	10	120
Green Range-1	10	130
Green Range-2	10	140
Green Range-3	10	150
Green Range-4	10	160
Blank Area	160	
Total Speedometer Area	320	

Pointer Data	
Pointer Value	88,88889
Pointer width	3
Blank Area	228,1111
Category Average	2,22
%	55,55556
	0,5556

Figure 30: Speedometer Data

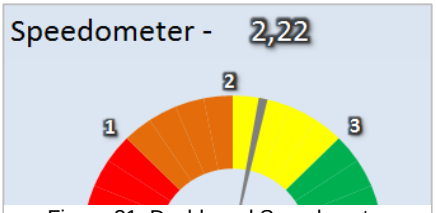

Figure 31: Dashboard Speedometer

5.3.2.6 Step 6 - Historical vs. Current Data

To provide the users with a comparison view of the current performance pyramid and the previous month or week performance pyramid, a macro was developed. This macro will copy the current pyramid to the right hand side of the dashboard and create a new pyramid with the historical data on the left. Having both pyramids side by side will enable a clear comparison procedure for MT members. Macro code can be found in Appendix 9 under the name of Macro 2.

Section one is in charge of copying the current performance pyramid and pasting it in the right hand side of the dashboard. Section two is responsible for opening all the data sources and closing them so information can be updated to the dashboard secondary data worksheets in order to allow section three to extract the previous month or week performance. Section four updates the table of number of categories per color which serves as a basis for the speedometer data. This will give the new overall performance value for the historical data. Last step is the creation of two textboxes under each pyramid just to indicate which one is which. Figure 32 is an example of the view enabled by this macro to the user, where the two performance pyramids are shown, with the corresponding data, allowing comparisons to be made and further discussions. It is clear when a category changes from one color to another and MT members can then go one step deeper into analyzing what was the cause of the change of color, meaning change of performance. To trigger this macro, a button is added to the dashboard's main view.

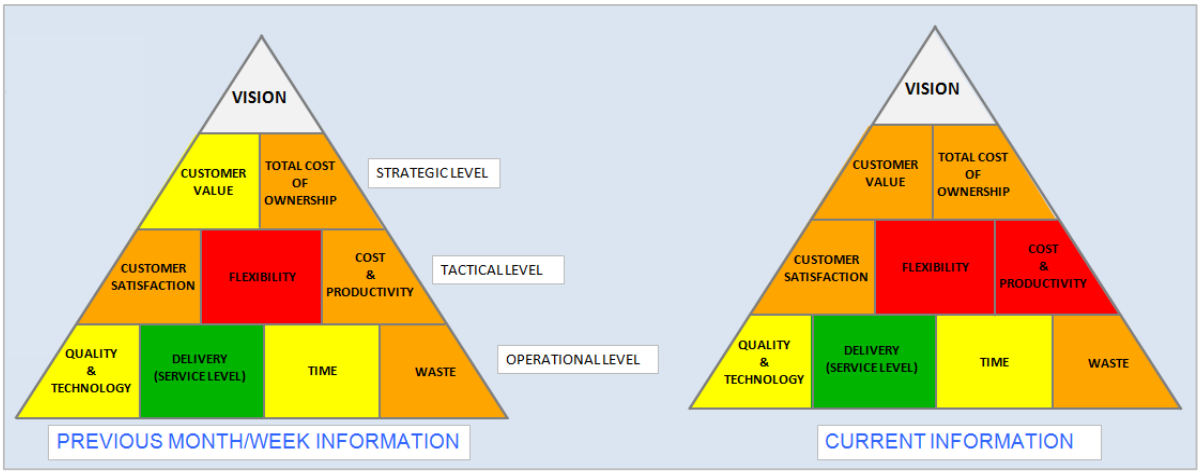

Figure 32: Historical vs. Current Data Pyramids

5.3.2.7 Step 7 – Develop Other Supporting Macros

To support the correct functioning of the dashboard, there are some key secondary macros that needed to be developed. These are described in the rest of Appendix 9.

5.3.2.8 Step 8 – Combining All Elements to Dashboard Main View

Taking into account all of the above information, the dashboard can be constructed. Figure 33 provides de dashboard's main view, where users can instantly see the performance pyramid and the performance color of each category, the speedometer value provided by the table with the number of categories per color, the buttons to trigger the update information macro, the comparison with historical data macro and the return to normal view macro. Percentage of data available is also in this view until this reaches 100%. This is the only feature that is manual, because it is a temporary characteristic of the dashboard's main view. As new data becomes available, this will need a manual adjustment. Further description about this will be made know later in this chapter.

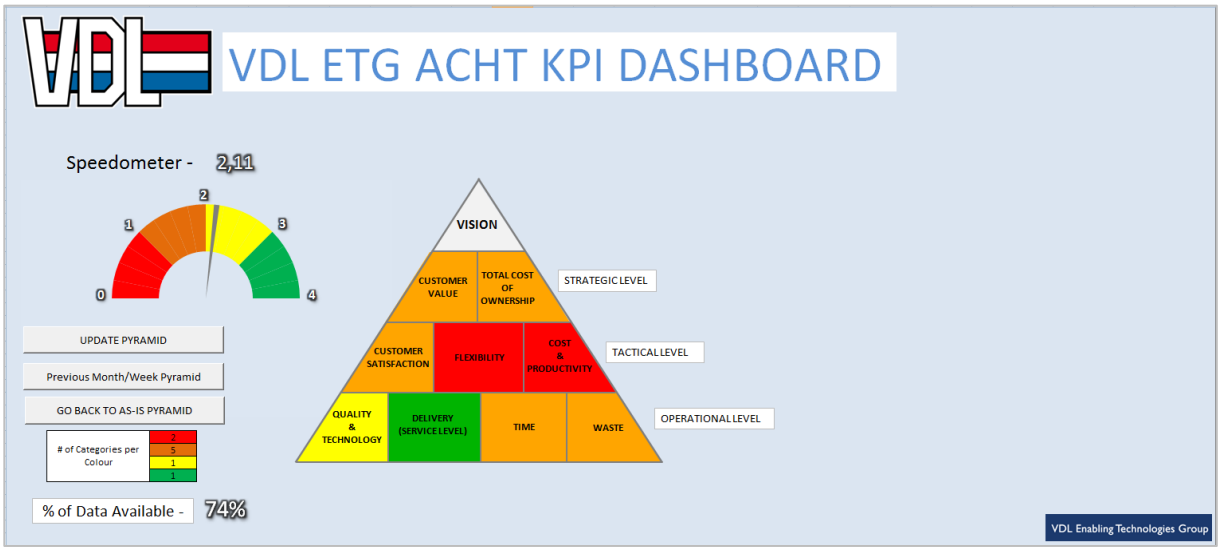

Figure 33: VDL ETG's Dashboard

This view is inspired in the general director's and MT members' favorable opinion on "Less is more". A very simplistic view that serves as the first point of contact document for the monthly meetings where further analyses are made based on this view. All categories have hyperlinks associated to them so to go to the corresponding worksheet, users just need to click on top of the category. Figure 34 provides the view of the dashboard when the historical data macro is triggered. The changes in performance that occurred in the interval of time are clear, meaning that the speedometer's value is going to change.

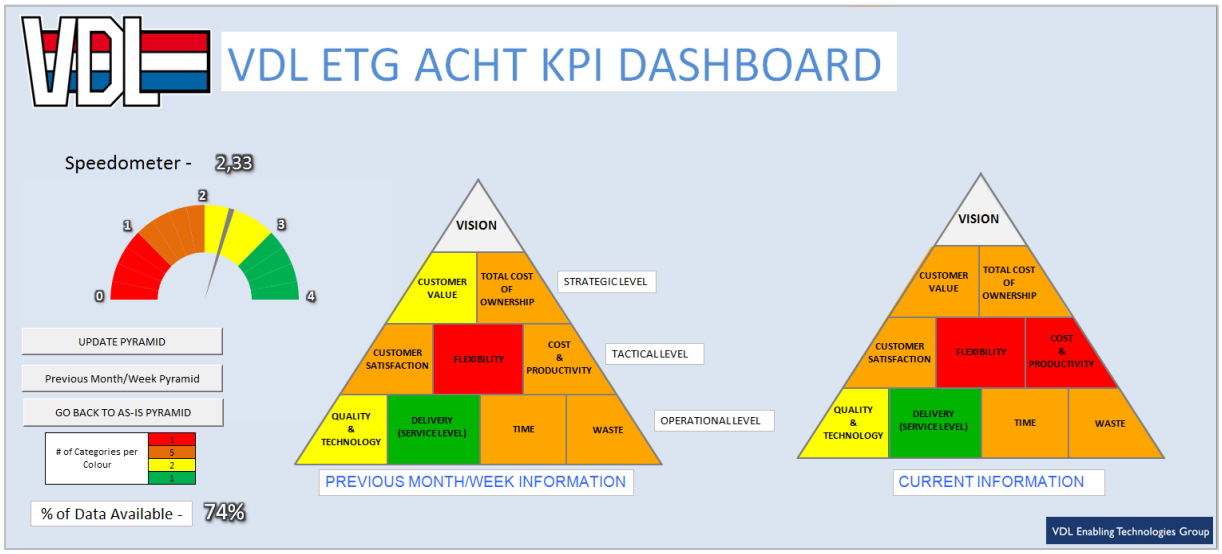

Figure 34: Dashboard with Comparison View

5.3.2.9 Step 9 – Establish KPI Library

This worksheet is where all the KPI information is consolidated. It is made up of all KPIs' templates and it is easy for the user to consult whenever necessary. All templates are depicted in Appendixes 10 to 14 except for the template corresponding to the newly implemented KPIs, which have already been introduced. All unavailable data is represented as a blue cell. As seen above in section 5.3.2.1, all of these KPI templates are in the corresponding category worksheets.

5.3.2.10 Step 10 – Develop Explanation Worksheet

To conclude the Dashboard Construction section, the reader should have awareness towards the explanation worksheet, the last remainder element of the dashboard. This worksheet is key to future users since it provides the necessary information for anyone to understand the dashboard. It starts with a brief explanation of the performance pyramid and lists all KPIs that constitute the pyramid. The ranking information is also found here, so that in case any user is in doubt of the ranking procedure, they can quickly consult the explanation worksheet.

Figure 35 demonstrates the initial view of the explanation worksheet where all of the above descriptions are included. It also provides some quick statistics about the performance pyramid as to the number of categories and number of KPIs. Noting that further information about the KPIs *per se* is found in the KPI Library, and for user-friendly purposes, it includes a button that by clicking it, directs users to this worksheet.

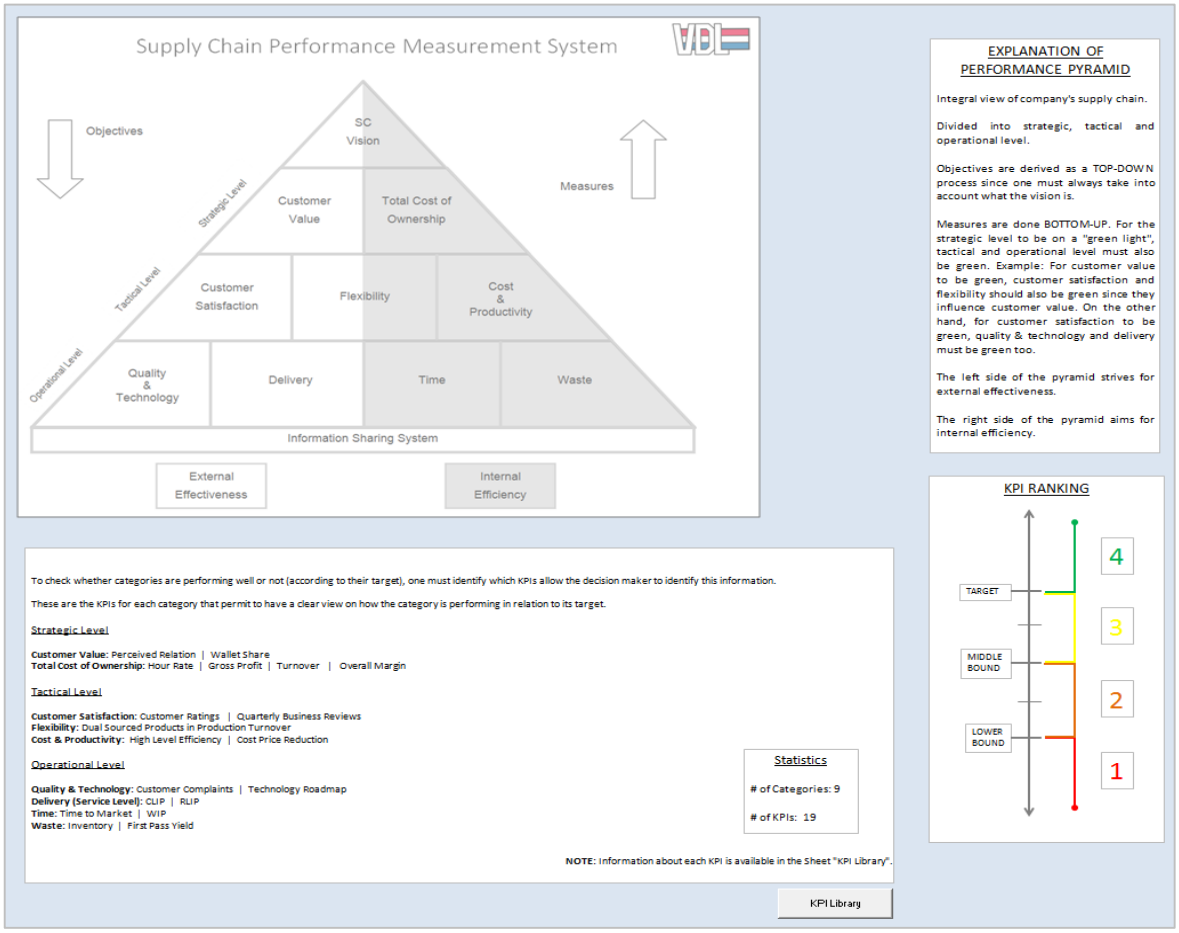

Figure 35: Explanation Worksheet Initial

When users scroll down this worksheet, they can find information regarding the weigh factors table and how it works, as well as the percentage of the available information provided by the dashboard at that moment. Currently, 74% of data is available and, as seen in Figure 36, when the Explanation worksheet, user can have a detailed view as to what type of data is missing (corresponding to what KPIs). Naturally, the use of blue filled cells when information is not available is also explained.

Also included in this worksheet is all the speedometer data described in section 5.3.2.5., but the spotlight of the Explanation worksheet is the macro information segment. All macros included in the document are mentioned and a brief description of their function is available. The flexibility offered by the dashboard model is then made known when a description of the steps to take when one wants to add or remove a KPI to a category are identified. All necessary alterations to the corresponding category's worksheet are identified so there is room for the new KPI information, as well as all the alterations required at the macros' level. This allows knowledge for anyone to be able to perform these changes.

All the above aspects make up the explanation worksheet, providing enough insight for any dashboard user to fully understand what is being analyzed and how to make alterations in case needed.

Now that all the development process of the dashboard has been described, the deployment phase of the RADAR logic is terminated.

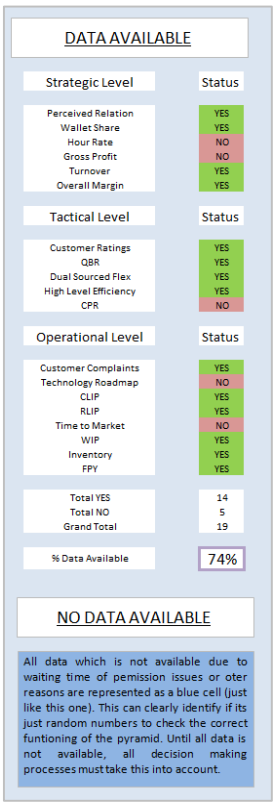

Figure 36: Data Availability Information

5.4 Assess & Refine

The final step of the RADAR logic is “asses & refine” and this is identified by block 7.4 of the research framework and aims to answer research question 4(d) by identifying the results of the deployment and explaining all alterations needed. The following sub-questions are answered:

1. Assess if all the MT members’ requirements are fulfilled by the deliverable made. How?
2. What is the general director’s and MT members’ feedback on the deliverable?
3. What alterations must take place?

5.4.1 Assessing MT Members’ Requirements

Establishing a clear communication tool was the main requirement, and to the opinion of the researcher, it was entirely fulfilled given that a centralized KPI dashboard was developed where meetings between MT members and the general director can occur with only one tool. The model provides an integral performance view where the chosen SCPMeS is integrated in it, making performance levels for each category very visual. Plus, the existence of the speedometer allows the integral performance to gain a general value. This value is dependent on the number of categories at each of the four possible colors. The colors of each category correspond to the weight factors and KPIs’ status of the corresponding category. Given this, the integral performance view requirement is fulfilled. Table 15 provides a summary of all the requirements towards the deliverable and points out whether they have been fulfilled or not and how.

Table 15: Assessing if MT Members' Requirements are met

MT Requirement	Fulfilled?	How?
Clear Communication Tool	Yes	KPI dashboard, 1 tool
Integral Performance View	Yes	Categories' color changes, weight factors, speedometer
High Level KPIs + One Step Deeper	Yes	High level KPIs with secondary information available
Historical vs. Current Status	Yes	Macro enables comparison view with two pyramids
KPI Library	Yes	Standardized info and templates
Automation	Partially	Most is automatic, some manual. Permissions take too much time
Flexible	Yes	Anything can be changed, and instructions to do so are provided
Data Accuracy	Partially	Hard when data source itself does not contain accurate information

The performance pyramid offers a very high level overview, where only the categories' names are visible with their corresponding color based on performance levels. For users to have access to more detailed information regarding why the category is performing as-is, a one step deeper analysis can be made by using the category's worksheet. This is where all information about the KPIs can be found, as well as their status. If users would like to go even one step deeper, then the owner of the KPI in question must provide additional information about the eventual PIs that exist, hence justify what has happened for performance levels of that KPI to be as-is. This requirement is considered fulfilled for all the above mentioned reasons.

Historical versus current data is now accessible since the corresponding macro was developed and a simple button to trigger it was made available to users in the dashboard's main view. This enables insight towards the previous status of the performance pyramid and the previous speedometer reading. Users can easily compare both scenarios and draw further discussions from it. It is believed by the researcher that this requirement is fulfilled.

Regarding the existence of a KPI library, this is available but not all data is, since permissions to access this information were not granted or the waiting process was still active. The existence of such worksheet allows information to be standardized into templates, were all KPI definitions are provided, avoiding any confusion from this. It is very important that MT members discuss about the same things, and know what they are discussing. One could argue that given the fact that not all data is available to complete the KPI library, stating that the requirement is not fulfilled, but the structure is there and all available data is connected to this worksheet, leaving only the rest of the unavailable data to be filled in. For this reason, the researcher considered that this requirement is fulfilled.

Automation was one of the most complicated requirements to take into consideration because not all MT members' KPI dashboards have the automated characteristic. Especially the relatively new KPIs that have less than one year (example: high level efficiency). When permissions were granted to gain access to the right folders, automation was developed to extract the correct data to the centralized model. Given all of the above, and attending to the fact that there is one KPI that requires manual input to be updated, the automation requirement is considered partially fulfilled. Nevertheless, in the recommendations section further on, this will be made know and the future actions to fulfill entirely this requirement will be made know.

MT members mentioned they would like to have a rather flexible model, so that from time to time it can be altered, as in adding a KPI to a certain category or removing one. Since instructions are provided in case this is needed, and construction of the dashboard was made taking that into account, the requirement for flexibility is entirely fulfilled.

Lastly, data accuracy is always a requirement, no matter what company or what industry it is in. Best decisions are made when data is accurate and when decision makers know what is actually going on and have the most up to date data. All information links were made, to extract data from the business intelligence platform, which provides the most up to date information. Yet, there is no guarantee that the information made available is accurate. This is a recurring problem at VDL ETG, especially to do with PARTS production data. It is easy for someone to forget to fill in data regarding the simplest process and so for all the above reasons, the requirement for data accuracy is considered partially fulfilled.

5.4.2 General Director and MT Members' Feedback

Once the dashboard's structure was entirely ready, working properly and all available links were established, a follow-up meeting took place with some MT members and the general director of VDL ETG. The main purpose of the meeting was to present the dashboard and collect all possible feedback from them.

Most comments regarding the dashboard were positive. The fact that it groups KPIs into categories and hierarchically into strategic, tactical and operational levels presents a big advantage. This provides prioritizing system for the KPIs, it is clear where the focus should be, avoiding wrong resource allocation. The dashboard's main view is visually strong, where one can immediately identify the status of performance in each category.

The historical versus current data feature was highly appreciated, since it allows clear comparisons to be made. Furthermore, it was mentioned that a view into the future or trends would be interesting to have. MT members and the general director believe that one of the strongest aspect of the dashboard is the KPI library. Providing clear definitions to KPIs and making that information available will avoid all the miss understandings caused by the same named KPIs with different meanings.

The fact that this dashboard presents a very high level overview, key stakeholders believe that using it on a monthly basis would be unnecessary. Utilizing such model for their bi-annual meetings should make more sense, since they consider the dashboard as having a "mirror" function. It is a clear view of the as-is situation of VDL ETG. Having this dashboard as the first point of contact of data in these meetings would then lead the key stakeholders to the correct direction, enabling them to identify what areas should receive bigger attention.

The category division is also appreciated by the fact that it can serve as milestones. Through the bi-annual meetings, the dashboard can be used to see how performance levels are and the focus for the following six months could be to bring a specific category to the green level. Once this was successfully achieved, focus shifts to another category that is not yet green. All actions during the six months must take into account that increasing performance of the focusing category will not compromise the categories which were already at the green performance level.

MT members assigned an engineer that is specialized in excel and macros to exchange all the know-how of the model regarding all the codes. Even though all information is available in case users would like to add/remove a KPI to a category, key stakeholders advised for this meeting to take place.

Discussion about the future owner of the dashboard was carried out. The person responsible for it is, of course, the general director, whereas agreement towards the owner of the model's maintenance is obtained for the TQ manager.

Given all the above, the overall feedback was positive and the model was well accepted. There are high chances that once all data is made available, implementation will move forward in the bi-annual meetings.

5.4.3 Refining

First step for perfection is to make all data available and create the external links to it. This will provide the entire picture of performance with the highest accuracy possible. Once this is completed, the next refining action should be to implement the other KPIs considered "must haves" but were not implemented since there were other priorities. As mentioned before, SC has its dynamic characteristic so this model must be as dynamic as possible. For this to happen, on a yearly basis, KPIs should be revised to see if they are still to be in the high level overview or not. Possibly, over time, KPIs will be substituted by others, but this needs to be taken into consideration towards the dashboard so all information remain up to date.

5.5 Chapter Conclusion

This chapter represents steps 3 of the chosen SCPMS framework, depicted in Figure 2. The objective was to define the action plan for step 4 to be developed successfully. In other words, it represents the design for implementation of the SCPMeS that is part of the SCPMS. Implementation of this design is not part of the scope of this research because of the time frame, hence the design for implementation of the SCPMS was not developed. This chapter is divided accordingly to the four steps of the RADAR logic. The main conclusions of these steps are described next.

As mentioned in the initial step (result target) of the RADAR logic, several MT members' requirements for the design for implementation of the SCPMeS were made known. These are; a clear communication tool for decision making, an overall view of performance, high level information with more detailed data when demanded, historical versus current data view, a KPI library, the automated feature, flexible characteristic and data accuracy. The following step (approach) presents to the reader the strategy made to fulfill these requirements and how it will individually address all of them. The deliverable proposed is a communication tool that facilitates MT members to make decisions by providing them an integral overview of how the company is performing and what areas need more focus. Deploy is the third phase, where the strategy is set, its structure is presented and the deliverable is constructed. All 10 steps to create the deliverable are made known.

The final step of the design for implementation is related to assessing and refining the approach. Mostly all requirements are entirely fulfilled except for automation and data accuracy. Both of these are partially fulfilled because automation is not achieved at 100% (due to manual input KPI dashboards from MT members) and because data accuracy is very hard to achieve at its fullest. Recommendations to fulfill these requirements are to automate all external data sources so once all data is available, it can be linked to the dashboard and it may all be automated. Regarding data accuracy, more control over the registration process of information that will then be translated into the business intelligence platforms.

To sum up, regarding the proposed SCPMS shown in Figure 2, steps 1, 2 and 3 are finalized. Step 4 is the implementation of the deliverable developed in this chapter and step 5 is managing the performance by reporting, reviewing and making decisions. Once step 5 is complete, the cycle starts again. As mentioned before, review of KPIs is a must and should be discussed on a yearly basis. As soon as all these steps are complete, the SCPMS can be implemented into the case company. Then again, due to time frame, unfortunately this will not be in the scope of this research and is therefore considered a highly recommended future work.

6 Conclusions, Limitations, Future Work & Comments

6.1 Conclusions

Lastly, the research has arrived at the final block of the research framework, block 8, where one deduces if the problem statement has been answered or not. This research addressed internal SCPMMSs for the case company, more specifically, it is a proposition to partially answer (due to time constraints) the problem statement: *"How can successful internal supply chain performance management and measurement systems be designed for implementation at VDL ETG, driving overall customer value maximization at the lowest possible cost?*" This was done by answering four main research questions that were defined at the beginning of the research and are briefly answered next.

The first and second questions are answered in Chapter 2. They are defined as "*What is the theoretical background on the characteristics, design and implementation of integral SCPMMSs?"* and "*Which specific conceptual methods and approaches apply to SCP in the high tech manufacturing industry, and/or high mix & low volume, and why?"* Here, it is made clear that SC strategies are directly linked to SCP and the ideal SC strategy for the case company is identified. Subsequently, taken into account the context of this research, the SCPMS framework was developed. Since it is highly acknowledged that management cannot exist without measurement, there was a clear need for a SCPMeS. Three frameworks are analyzed, coming to the conclusion that the best fit is the SMART pyramid. Theoretical optimal KPIs for each category of the SMART pyramid are made known.

Chapter 3 dealt with the explanation of how data collection was going to be executed and all the configurations of the scientific research design were made. Moreover, to answer research question three, "*How can this effectively be applied to VDL ETG to drive customer value and lower total costs?"*, Chapter 4 is divided into three sections. The AS-IS situation represents the first section and answers "*What SCPMeSs and SCPMaSs do the stakeholders of VDL ETG currently apply?*" Several interviews with the key stakeholder panel are done to come up with the KPIs in use at each department and then correctly placed into the SMART pyramid. Reviewing of these KPIs is also identified.

The second part of Chapter 4 is related to the TO-BE scenario where the following question is answered: "*How should the chosen SCPMeS framework be effectively applied for VDL ETG?"* The ideal KPIs for VDL ETG (theoretically and also in terms of opinions derived by the stakeholders) are identified. The last section of the related chapter is the closing of the gaps between the AS-IS and the TO-BE scenarios. The following question is answered: "*What is the final version of the chosen SCPMeS framework, taking into account all possible relations to business impact?"* After comparing the AS-IS with the TO-BE situation, the missing KPIs are identified as "must haves". Due to the time frame of this research, the top priority KPIs to implement (hence gaps to be closed) were identified based on empty categories within the performance pyramid. Three KPIs are implemented as an attempt to complete the pyramid and for all its categories to contain at least one KPI. Once this is achieved, the final SCPMeS is derived (for the time being).

Chapter 5 addressed the following question: "*What is the action plan that will enable the design for implementation of the SCPMMSs at VDL ETG?"* Given the time span of the research, the design for

implementation provided refers only to the internal SCPMeS. To successfully achieve this, the previously mentioned question was answered in four steps regarding the RADAR logic. First step's question, referring to the results target, was defined as "*What are the expected results from the design for implementation?"* All the requirements from MT members were made known, giving enough insight to develop a personalized approach to the design for implementation.

The approach is the second step where the following question was answered: "*What is the chosen approach for the successful design for implementation of the frameworks?"* This section's aim was to make the reader aware of how the approach developed aimed to fulfill all requirements presented by the MT members. It was made known that the deliverable is a communication tool in the form of a high level KPI dashboard that facilitates users to make better decisions by gaining access to an integral overview of how the case company is performing and what really needs to be improved or receive a bigger focus. The SCPMeS is the core element of the dashboard where all categories change color based on their performance level.

Step three of the RADAR logic is "deploy" and it represents the approach being carried out. This section answers the question "*How will the deployment proceed?"* The KPI dashboard structure is explained and all the 10 construction steps are identified. To complete the design for implementation, an assessment and review was made towards the deliverable to accomplish the last step of the RARAD logic. This was established by answering the following question "*What are the results from the design for implementation?"* This segment analyzes if all the requirements presented are fulfilled by the deliverable or not. Recommendations to fulfill all the unfulfilled requirements are developed in the chapter conclusions. Furthermore, feedback meetings were taken place with the MT members and the general director and all the input was made known here. Positive reactions were identified with the strong possibility of a real implementation in the bi-annual MT meetings with the general director.

All of the information up to this point represents the conclusions drawn from this research. It is strongly believed by the researcher that a vigorous insight regarding how to successfully design for implementation a SCPMeS at VDL ETG driving overall customer value maximization at the lowest possible cost was provided. Next, the limitations of the research are presented.

6.2 Limitations

It is imperative to create awareness towards the fact that the frameworks developed in this research are not a one-size-fits-all. They represent a tailored design and all configurations associated to it in the high tech, high mix & low volume industry. For these frameworks to be implemented in a different industry (specially the SCPMeS), one must derive the vision, and from that, decide what are the categories belonging to the strategic, tactical and operational level and what KPIs enable decision makers to identify performance levels of the corresponding categories.

In conclusion, when the SCPMeS is derived, the entire design for implementation procedure made in this research is applicable. Making it rather simple to proceed onto the measurement (step 4 of the SCPMS) and deploy the performance management phase (step 5 of SCPMS). Here, decision makers must manage performance levels of the supply chain to ultimately achieve the company's vision.

6.3 Future Work

Future work includes the implementation of the SCPMeS at VDL ETG (implementation of the KPI dashboard) to execute step 4 of the chosen SCPMS where performance measurements are taken place. Once this is known, step 5 can take place, where stakeholders manage performance levels to achieve the ultimate goal of maximizing customer value at the lowest possible cost.

This performance management step should take into consideration (over time) that the final proposed SCPMeS, demonstrated in Figure 12, has not yet been achieved. The three KPIs that were implemented were just related to the high priority gaps to close. Decision makers must bear in mind that all other KPIs drawn from literature review and discussions with MT members should be implemented to ultimately attain the desired TO-BE situation.

Validation of the implemented KPIs should also be executed, when enough data has been gathered so one can assess whether these are the right measures to use when evaluating performance levels in the corresponding categories.

Further theory development in the high tech industry can now be executed with the insight provided from this study, where one of the objectives was to contribute to current literature by filling in the gap between SCM and PMMSs. Since it is considered an exploratory research, enough awareness was created for additional validation on this study.

6.4 Comments

It was rather challenging to develop this research considering the techno social characteristic of it, where technological social enhancements are used to improve the way people interact with one another. Almost all aspects regarding completion of milestones of this study are somewhat political. This means that the social feature present in the research (interaction with all MT members and general director) and the various opinions that come with it was the toughest barrier. Everyone has their own judgment and attitude towards any given subject, naturally, but there is a lot of individualism amongst these key stakeholders. Individualism in the sense that they are too busy focusing on their department and not looking at the integral picture. Plus, it is not easy to address them and propose new “ways of working” because they are at the company for quite some time and they have survived until now, so why change?

Nevertheless, when one takes initiative despite all the negative comments and feedback and starts developing the idea anyways, and then has a follow up meeting with the stakeholders, it is a whole different world. From the moment that the concept is tangible, there is a lot of enthusiasm and support is provided. This is easily understood by the fact that at VDL ETG, people are more practical than “theoretical”. However, the researcher believes that there should always be a balance between both concepts to ultimately enable enterprises to become business differentiators.

In conclusion, the researcher considers that this is a strong dissertation and, considering the time frame, everything that could be executed and developed to prove that having SCPMMSs integrated with one another offers a robust management tool to drive customer value maximization at the lowest possible cost was done.

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Appendices

Appendix 1: Customer Value Worksheet

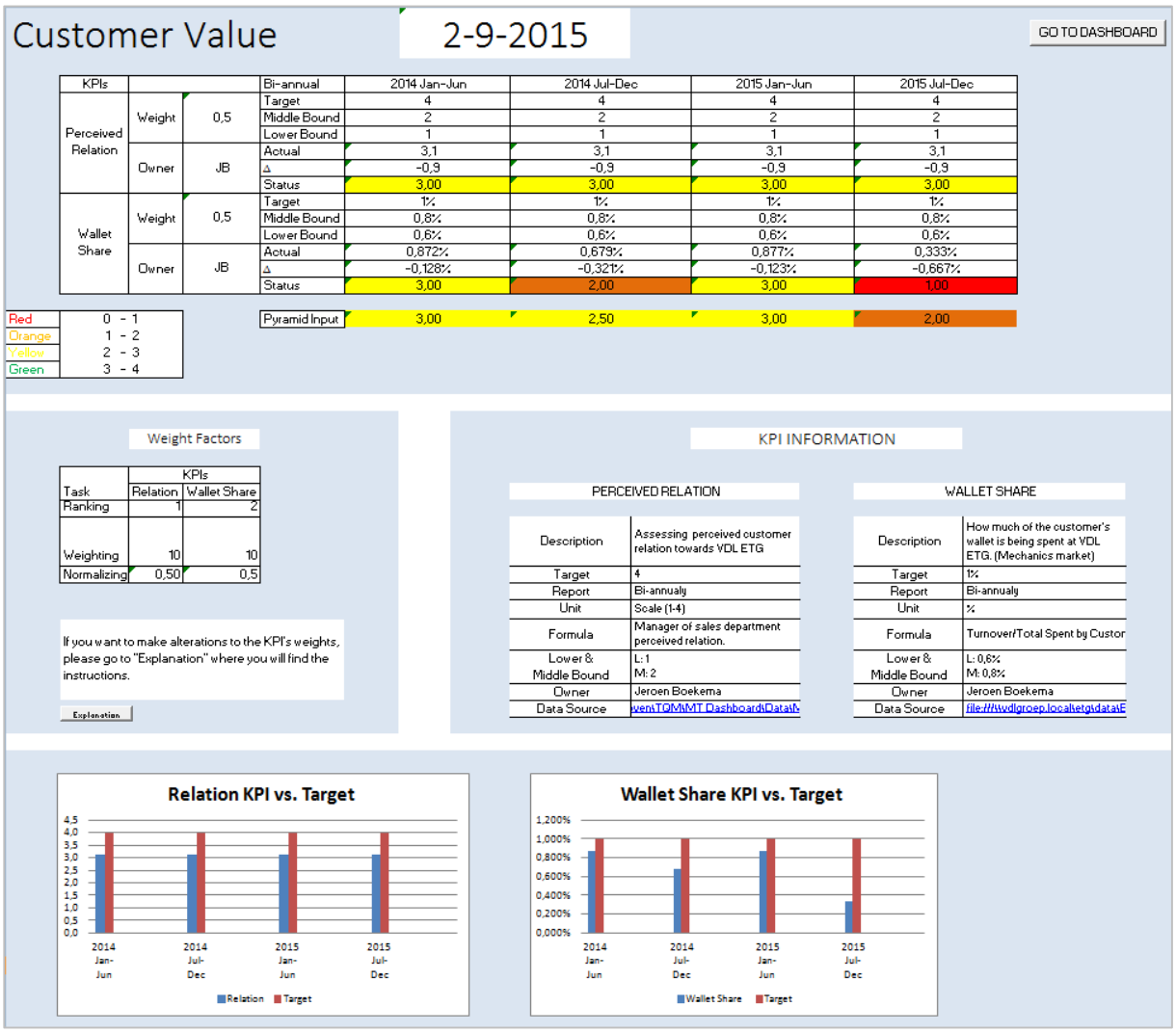


Figure 37: Customer Value Worksheet - Dashboard Secondary Data

Appendix 2: Total Cost of Ownership Worksheet

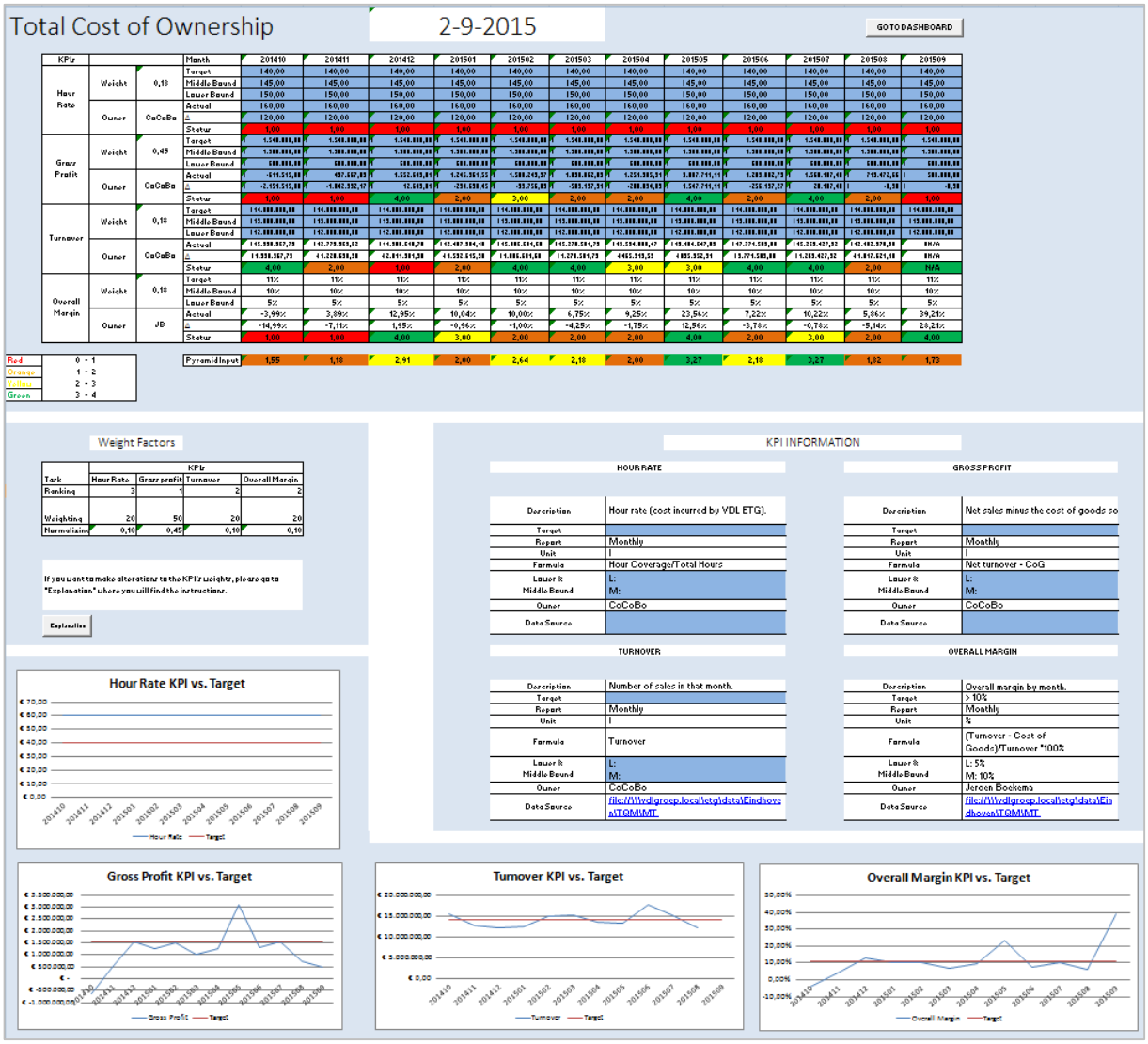


Figure 38: TCO Worksheet - Dashboard Secondary Data

Appendix 3: Customer Satisfaction Worksheet

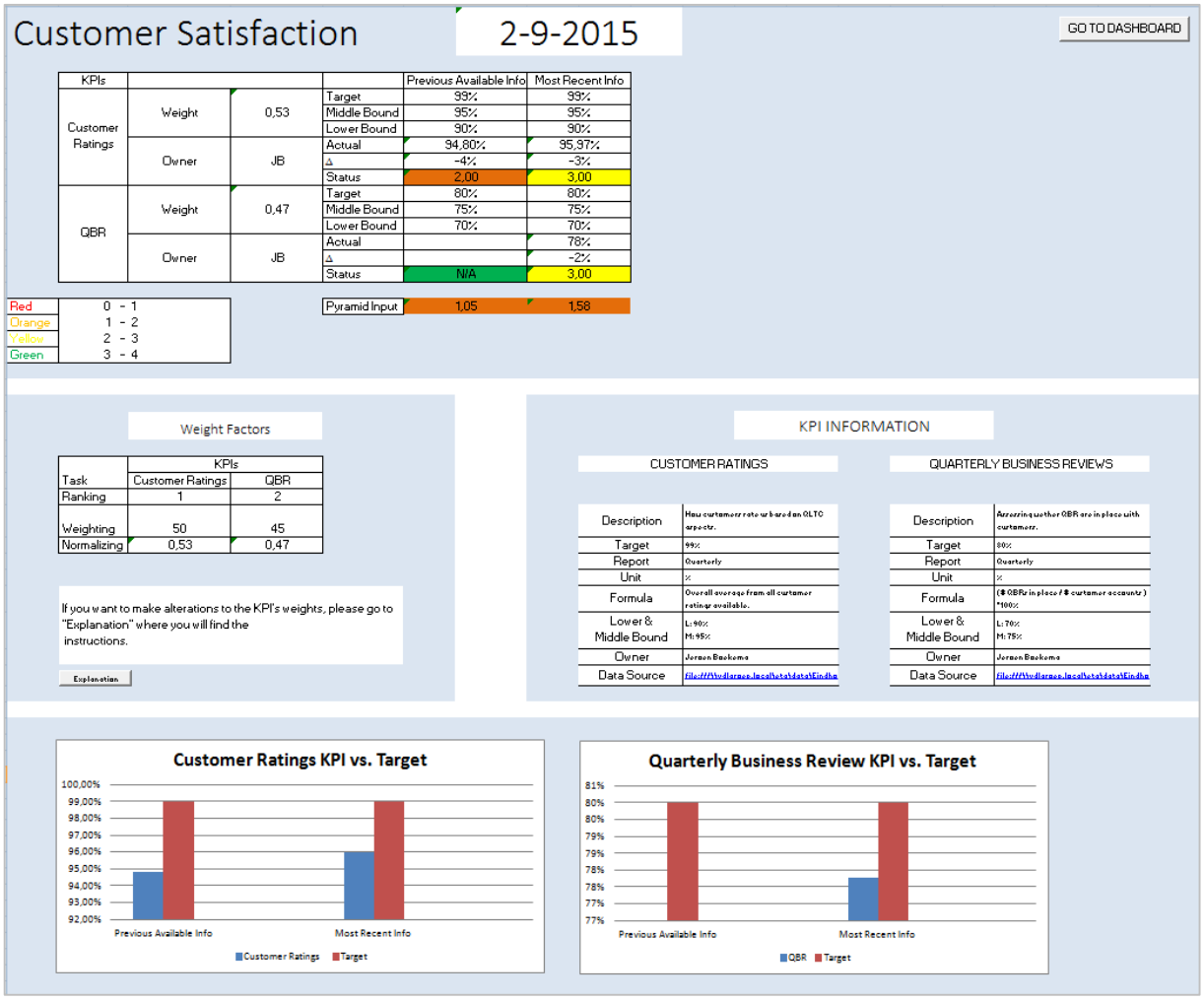


Figure 39: Customer Satisfaction Worksheet - Dashboard Secondary Data

Appendix 4: Flexibility Worksheet

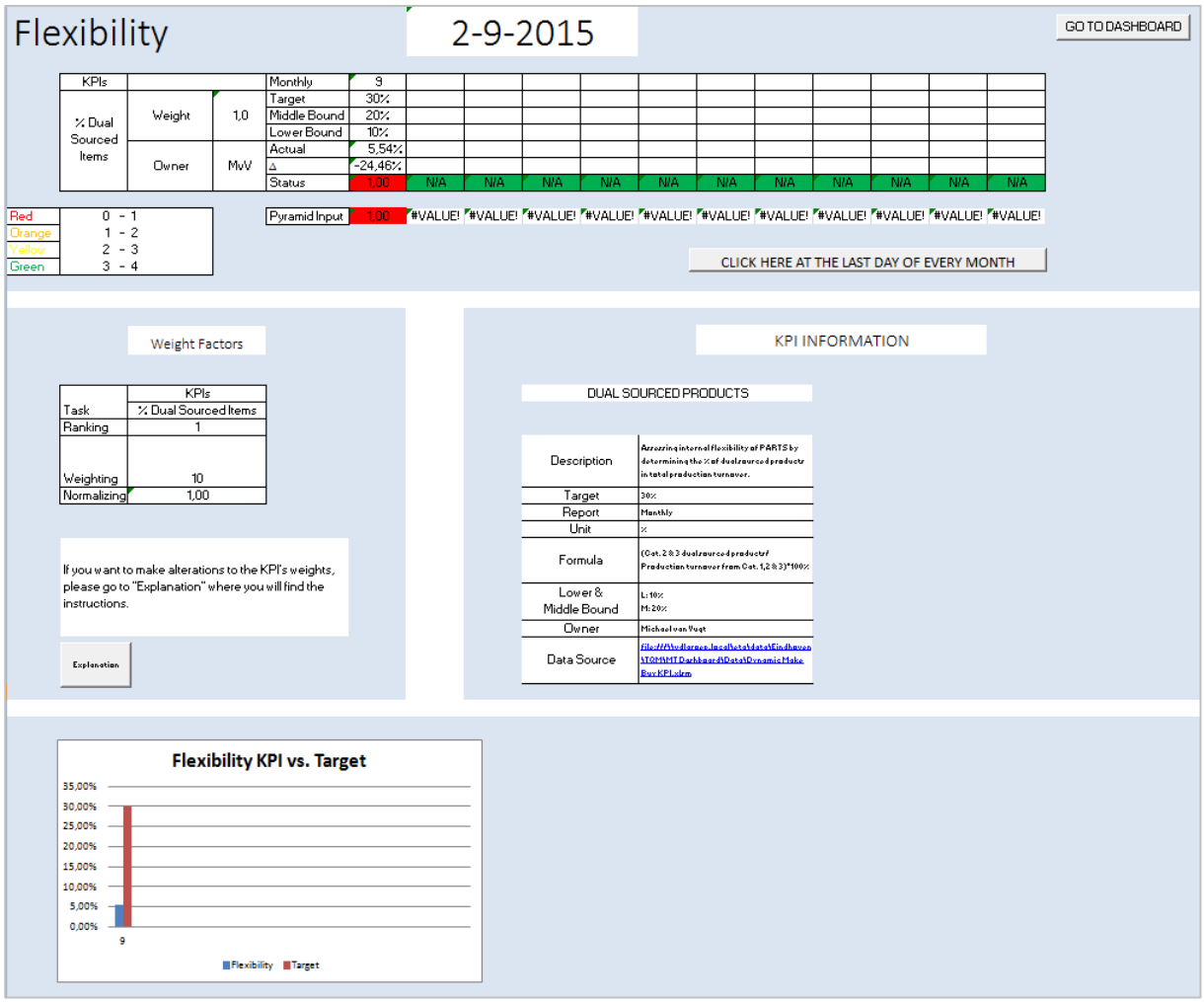


Figure 40: Flexibility Worksheet - Dashboard Secondary Data

Appendix 5: Cost & Productivity Worksheet

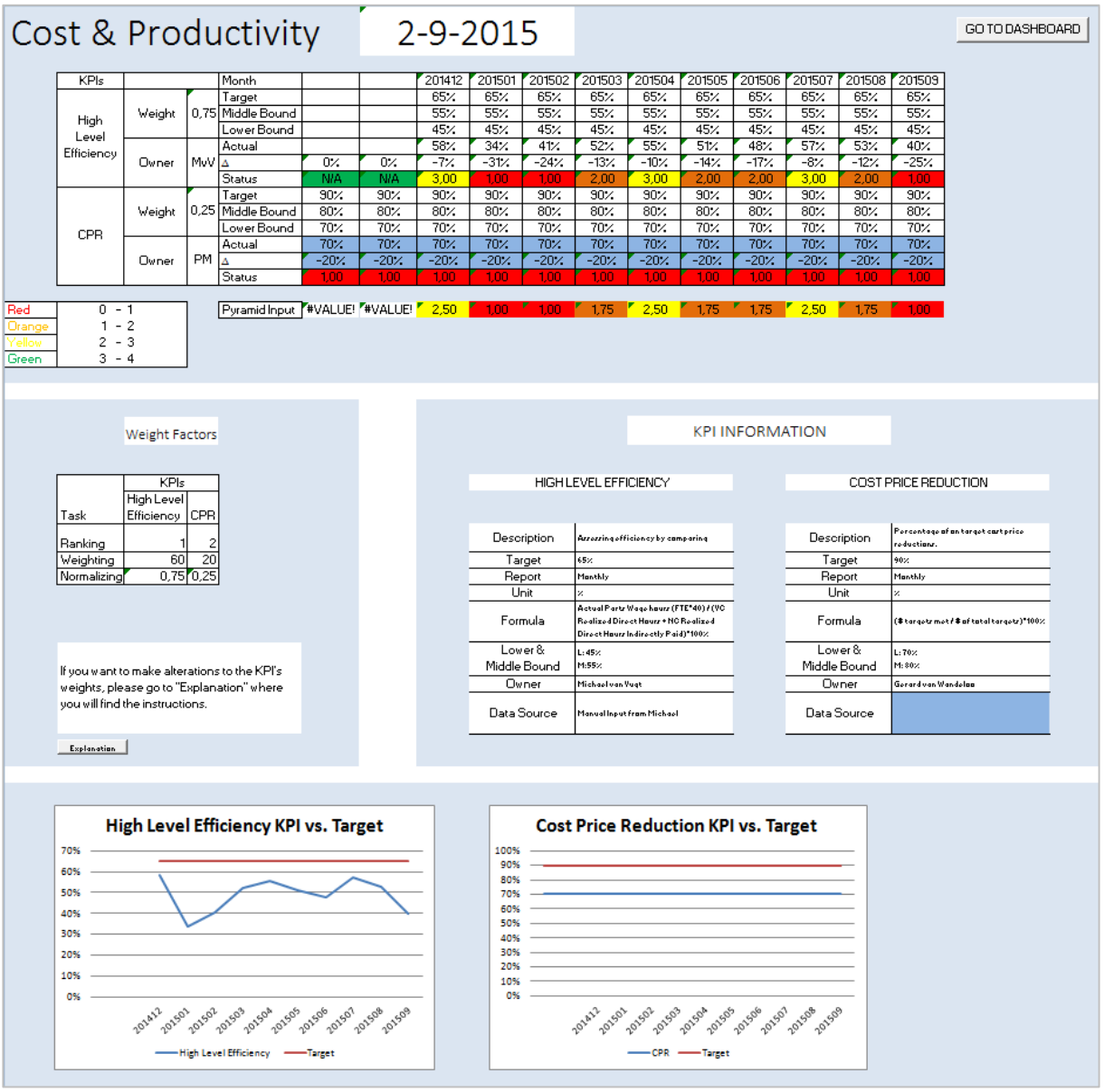
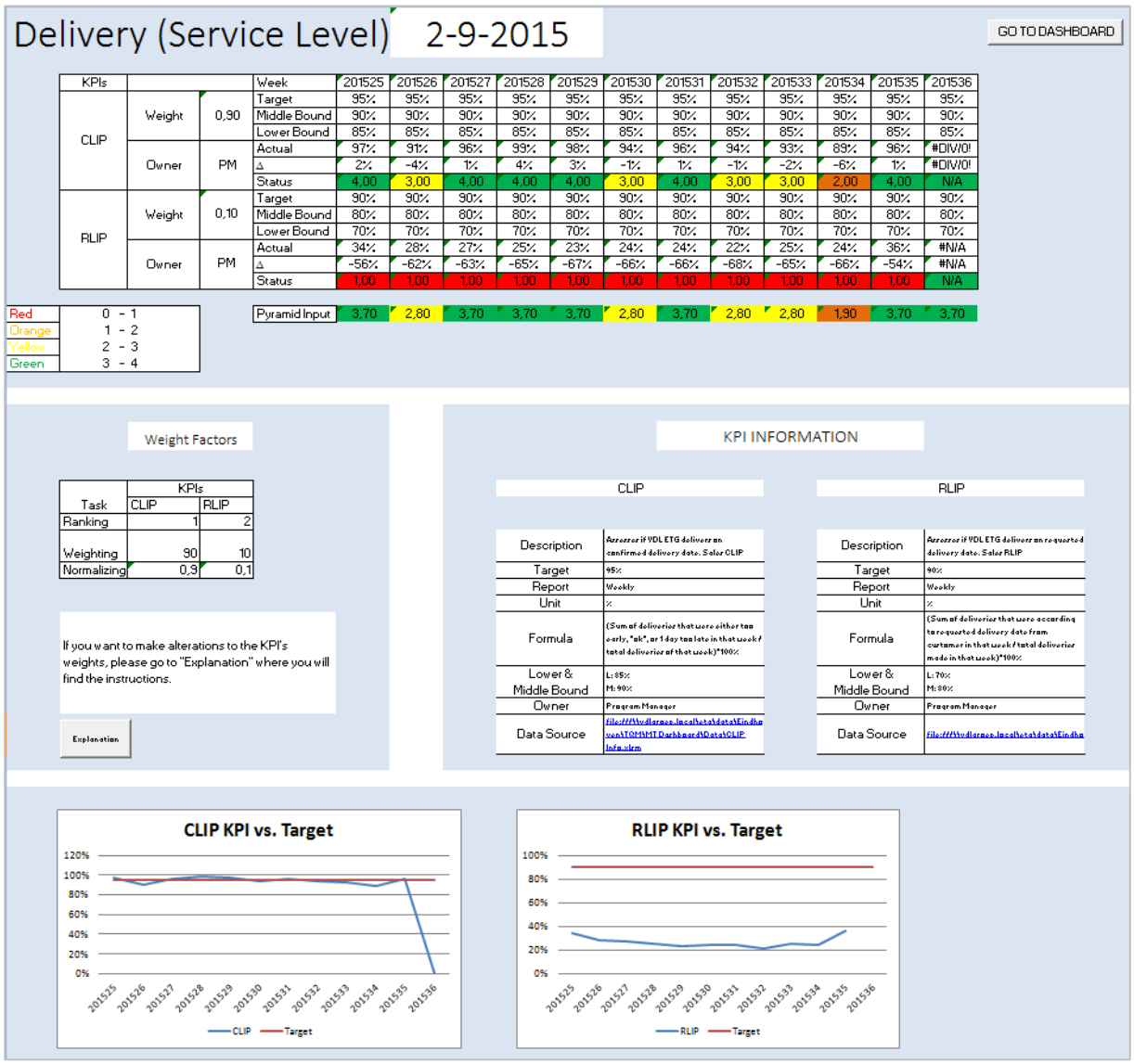


Figure 41: Cost & Productivity Worksheet - Dashboard Secondary Data

Appendix 6: Delivery (Service Level) Worksheet



KPIs			Week	201525	201526	201527	201528	201529	201530	201531	201532	201533	201534	201535	201536
CLIP	Weight	0,90	Target	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
			Middle Bound	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
			Lower Bound	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
	Owner	PM	Actual	97%	91%	96%	93%	98%	94%	96%	94%	93%	89%	96%	#DIV/0!
			Δ	2%	-4%	1%	4%	3%	-1%	1%	-1%	-2%	-6%	1%	#DIV/0!
			Status	4,00	3,00	4,00	4,00	4,00	3,00	4,00	3,00	3,00	2,00	4,00	N/A
RLIP	Weight	0,10	Target	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
			Middle Bound	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
			Lower Bound	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
	Owner	PM	Actual	34%	28%	27%	25%	23%	24%	24%	22%	25%	24%	36%	#N/A
			Δ	-56%	-62%	-63%	-65%	-67%	-66%	-66%	-68%	-65%	-66%	-54%	#N/A
			Status	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	N/A
Pyramid Input				3,70	2,80	3,70	3,70	3,70	2,80	3,70	2,80	2,80	1,90	3,70	3,70

Red	0 - 1
Orange	1 - 2
Yellow	2 - 3
Green	3 - 4

Task	KPIs CLIP	KPIs RLIP
Ranking	1	2
Weighting	90	10
Normalizing	0,9	0,1

Description	CLIP
Target	95%
Report	Weekly
Unit	%
Formula	(Sum of deliveries that were either too early, "ok", or 1 day too late in that week / total deliveries of that week)*100%
Lower & Middle Bound	L: 85% M: 90%
Owner	Program Manager
Data Source	file:///\\wdlarnge.local\data\data\Eindhoven\TOM\MT Dashboard\Data\CLIP Info.xlsm

Description	RLIP
Target	90%
Report	Weekly
Unit	%
Formula	(Sum of deliveries that were according to requested delivery date from customer in that week / total deliveries made in that week)*100%
Lower & Middle Bound	L: 70% M: 80%
Owner	Program Manager
Data Source	file:///\\wdlarnge.local\data\data\Eindhoven\TOM\MT Dashboard\Data\RLIP Info.xlsm

Figure 42: Delivery Worksheet - Dashboard Secondary Data

Appendix 7: Time Worksheet

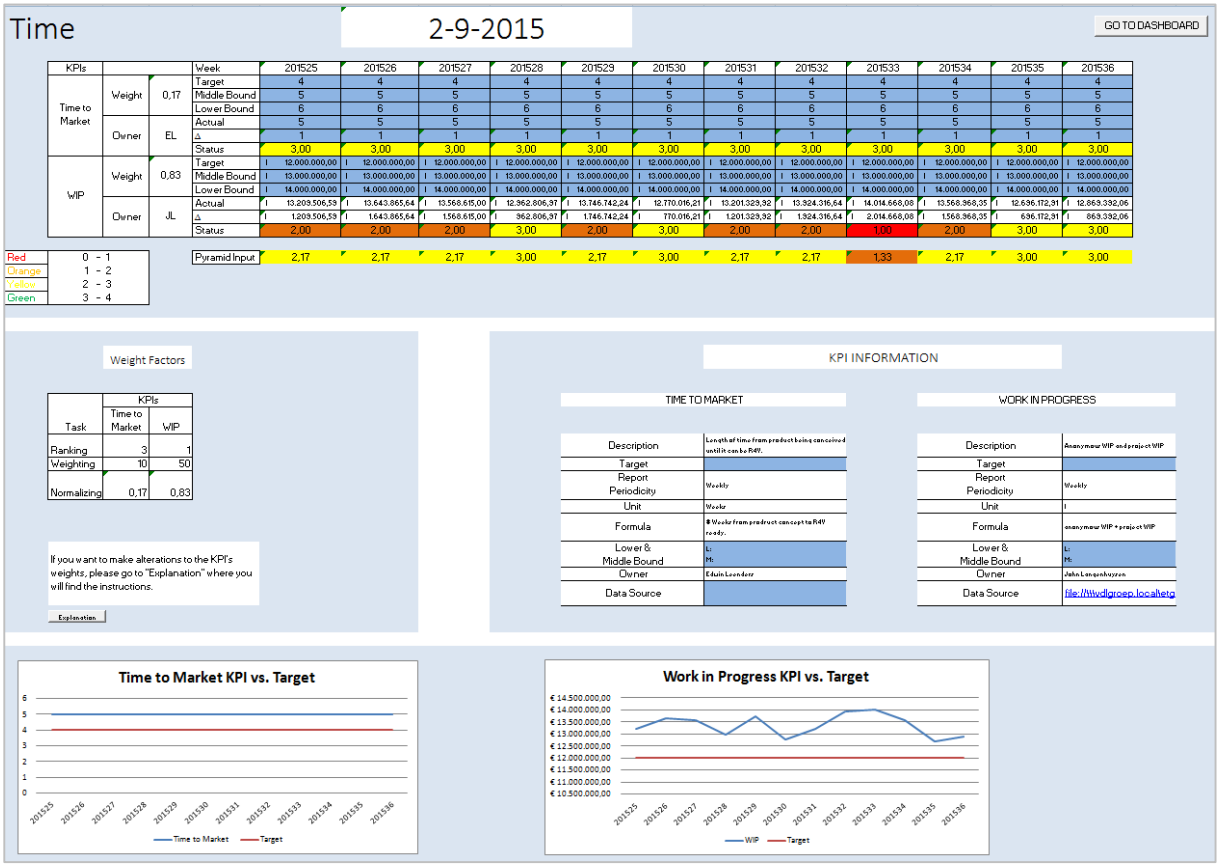


Figure 43: Time Worksheet - Dashboard Secondary Data

Appendix 8: Waste Worksheet

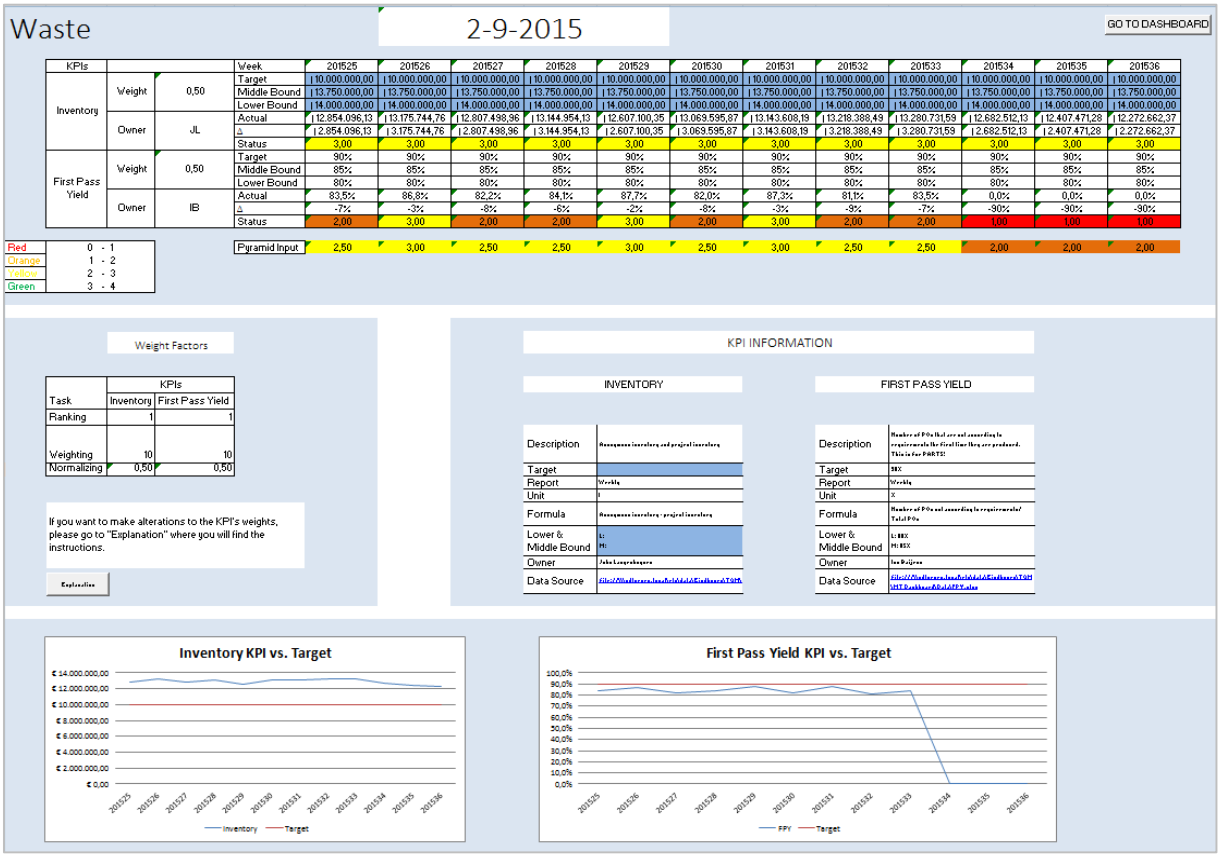


Figure 44: Waste Worksheet - Dashboard Secondary Data

Appendix 9: Macros

Macro1:

```
Sub Update_Pyramid_Colour()
'Next, all workbooks containing the data for dashboard will be opened and closed so the info is updated
'SECTION 1
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\CLIP Info.xlsm"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\RLIP Info.xlsm"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\Margin Report ETG + Wallet Share.xlsx"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\Dynamic Make Buy KPI.xlsm"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\WIP + Inventory.xlsx"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\Turnover.xlsx"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\Customer Ratings + QBR.xlsx"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\Reviews\Review PI Acht\PI_2015 Acht Share.xlsm"
ActiveWorkbook.Save
ActiveWindow.Close
'ATENTION: data regarding first pass yield located in file: M:\Eindhoven\TQM\MT Dashboard\Data\FPY.xlsx cannot be
updated since permission for all data source within this file is not yet available
'Next step is to fill in the colour of each category based on their status. The ranking is explained in the
explanation workbook
'SECTION 2
'Customer value data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Customer_Value")
    If ThisWorkbook.Sheets("Customer Value").Range("O17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Customer Value").Range("O17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C18").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Customer Value").Range("O17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C19").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Customer Value").Range("O17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C20").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'TCO data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("TCO")
    If ThisWorkbook.Sheets("Total Cost of Ownership").Range("Q29").Value <= ThisWorkbook.Sheets("Total Cost of
Ownership").Range("C29").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("Q29").Value <= ThisWorkbook.Sheets("Total Cost
of Ownership").Range("C30").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("Q29").Value <= ThisWorkbook.Sheets("Total Cost
of Ownership").Range("C31").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("Q29").Value <= ThisWorkbook.Sheets("Total Cost
of Ownership").Range("C32").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Customer satisfaction data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Customer_Satisfaction")
    If ThisWorkbook.Sheets("Customer Satisfaction").Range("H17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("H17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C18").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("H17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C19").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("H17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C20").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Flexibility data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Flexibility")
    If ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C11").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C12").Value Then
```

```
        .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
        ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C13").Value Then
        .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
        ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C14").Value Then
        .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Cost & productivity data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Cost&Productivity")
    If ThisWorkbook.Sheets("Cost & Productivity").Range("Q17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
        ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("Q17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C18").Value Then
        .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
        ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("Q17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C19").Value Then
        .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
        ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("Q17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C20").Value Then
        .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Quality & technology data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Quality&Technology")
    If ThisWorkbook.Sheets("Quality & Technology").Range("Q17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
        ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("Q17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C18").Value Then
        .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
        ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("Q17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C19").Value Then
        .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
        ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("Q17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C20").Value Then
        .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Delivery data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Delivery")
    If ThisWorkbook.Sheets("Delivery (Service Level)").Range("Q17").Value <= ThisWorkbook.Sheets("Delivery (Service
Level)").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
        ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("Q17").Value <= ThisWorkbook.Sheets("Delivery
(Service Level)").Range("C18").Value Then
        .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
        ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("Q17").Value <= ThisWorkbook.Sheets("Delivery
(Service Level)").Range("C19").Value Then
        .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
        ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("Q17").Value <= ThisWorkbook.Sheets("Delivery
(Service Level)").Range("C20").Value Then
        .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Time data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Time")
    If ThisWorkbook.Sheets("Time").Range("Q17").Value <= ThisWorkbook.Sheets("Time").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
        ElseIf ThisWorkbook.Sheets("Time").Range("Q17").Value <= ThisWorkbook.Sheets("Time").Range("C18").Value
Then
        .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
        ElseIf ThisWorkbook.Sheets("Time").Range("Q17").Value <= ThisWorkbook.Sheets("Time").Range("C19").Value
Then
        .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
        ElseIf ThisWorkbook.Sheets("Time").Range("Q17").Value <= ThisWorkbook.Sheets("Time").Range("C20").Value
Then
        .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Waste data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Waste")
    If ThisWorkbook.Sheets("Waste").Range("Q17").Value <= ThisWorkbook.Sheets("Waste").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
        ElseIf ThisWorkbook.Sheets("Waste").Range("Q17").Value <= ThisWorkbook.Sheets("Waste").Range("C18").Value
Then
        .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
        ElseIf ThisWorkbook.Sheets("Waste").Range("Q17").Value <= ThisWorkbook.Sheets("Waste").Range("C19").Value
Then
        .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
        ElseIf ThisWorkbook.Sheets("Waste").Range("Q17").Value <= ThisWorkbook.Sheets("Waste").Range("C20").Value
Then
        .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Once the pyramid is coloured accordingly, the information regarding the number of categories that are with status
red, orange, yellow and green needs to be updated. This is the data for the speedometer
'First set the values to zero and then update them
'SECTION 3
ThisWorkbook.Sheets("DASHBOARD").Range("C33:C36") = 0
'Customer value data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Customer Value").Range("O17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
```

```
    ElseIf ThisWorkbook.Sheets("Customer Value").Range("O17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Customer Value").Range("O17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Customer Value").Range("O17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'TCO data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Total Cost of Ownership").Range("Q29").Value <= ThisWorkbook.Sheets("Total Cost of
Ownership").Range("C29").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("Q29").Value <= ThisWorkbook.Sheets("Total Cost of
Ownership").Range("C30").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("Q29").Value <= ThisWorkbook.Sheets("Total Cost of
Ownership").Range("C31").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("Q29").Value <= ThisWorkbook.Sheets("Total Cost of
Ownership").Range("C32").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Customer satisfaction data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Customer Satisfaction").Range("H17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("H17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("H17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("H17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Flexibility data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C11").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C12").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C13").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C14").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Cost & productivity data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Cost & Productivity").Range("Q17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("Q17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("Q17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("Q17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Quality & technology data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Quality & Technology").Range("Q17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("Q17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("Q17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("Q17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Service Level
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Delivery (Service Level)").Range("Q17").Value <= ThisWorkbook.Sheets("Delivery (Service
Level)").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("Q17").Value <= ThisWorkbook.Sheets("Delivery
(Service Level)").Range("C18").Value Then
```

```
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("Q17").Value <= ThisWorkbook.Sheets("Delivery
(Service Level)").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("Q17").Value <= ThisWorkbook.Sheets("Delivery
(Service Level)").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Time data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Time").Range("Q17").Value <= ThisWorkbook.Sheets("Time").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Time").Range("Q17").Value <= ThisWorkbook.Sheets("Time").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Time").Range("Q17").Value <= ThisWorkbook.Sheets("Time").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Time").Range("Q17").Value <= ThisWorkbook.Sheets("Time").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Waste data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Waste").Range("Q17").Value <= ThisWorkbook.Sheets("Waste").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Waste").Range("Q17").Value <= ThisWorkbook.Sheets("Waste").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Waste").Range("Q17").Value <= ThisWorkbook.Sheets("Waste").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Waste").Range("Q17").Value <= ThisWorkbook.Sheets("Waste").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Finalize macro by going to the dashboard work sheet and provide a message to the user indicating that the
information and pyramid are up to date
'SECTION 4
Application.Goto Sheets("DASHBOARD").Range("A1")
MsgBox "Pyramid is up to date!"
End Sub
```

Macro 2:

```
Sub UpdatePastInfo_Pyramid_Colour()
'Conditionally formatting the pyramid info with the previous month or week information
'This macro will create a copy of the AS-IS pyramid and paste it to the right of the dashboard
'Then, it will gather all the previous month or week information and create a new pyramid with this info
'The previous month or week pyramid will appear on the left side of the dashboard
'Start by copying the AS-IS pyramid and pasting to the right side
'SECTION 1
Sheets("DASHBOARD").Activate
ActiveSheet.Shapes.Range((Array("Vision", "TextBox 61", "Customer_Value", "TextBox 62", "TCO", "TextBox 63",
"Customer_Satisfaction", "TextBox 64", "Flexibility", "TextBox 65", "Cost&Productivity", "TextBox 66",
"Quality&Technology", "TextBox 67", "Delivery", "TextBox 68", "Time", "TextBox 69", "Waste"))).Group.Name =
"Performance_Pyramid"
Sheets("DASHBOARD").Shapes("Performance_Pyramid").Copy
Application.Goto Sheets("DASHBOARD").Range("Q13")
ActiveSheet.Paste
Sheets("DASHBOARD").Shapes("Performance_Pyramid").Ungroup
'Next, the past info will be updated to the left side pyramid
'SECTION 2
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\CLIP Info.xlsm"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\RLIP Info.xlsm"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\Margin Report ETG + Wallet Share.xlsx"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\Dynamic Make Buy KPI.xlsm"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\WIP + Inventory.xlsx"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\Turnover.xlsx"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\MT Dashboard\Data\Customer Ratings + QBR.xlsx"
ActiveWorkbook.Save
ActiveWindow.Close
Workbooks.Open Filename:="M:\Eindhoven\TQM\Reviews\Review PI Acht\PI_2015 Acht Share.xlsm"
ActiveWorkbook.Save
ActiveWindow.Close
'ATENTION: data regarding first pass yield located in file: M:\Eindhoven\TQM\MT Dashboard\Data\FPY.xlsx
cannot be updated since permission for all data source within this file is not yet available
'Next step is to fill in the colour of each category based on their status. The ranking is explained in the
explanation workbook
'SECTION 3
'Customer value data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Customer_Value")
```

```
    If ThisWorkbook.Sheets("Customer Value").Range("L17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Customer Value").Range("L17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C18").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Customer Value").Range("L17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C19").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Customer Value").Range("L17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C20").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'TCO data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("TCO")
    If ThisWorkbook.Sheets("Total Cost of Ownership").Range("P29").Value <= ThisWorkbook.Sheets("Total Cost
of Ownership").Range("C29").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("P29").Value <=
ThisWorkbook.Sheets("Total Cost of Ownership").Range("C30").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("P29").Value <=
ThisWorkbook.Sheets("Total Cost of Ownership").Range("C31").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("P29").Value <=
ThisWorkbook.Sheets("Total Cost of Ownership").Range("C32").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Customer satisfaction data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Customer_Satisfaction")
    If ThisWorkbook.Sheets("Customer Satisfaction").Range("F17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("F17").Value <=
ThisWorkbook.Sheets("Customer Satisfaction").Range("C18").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("F17").Value <=
ThisWorkbook.Sheets("Customer Satisfaction").Range("C19").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("F17").Value <=
ThisWorkbook.Sheets("Customer Satisfaction").Range("C20").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Flexibility
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Flexibility")
    If ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C11").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C12").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C13").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C14").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Cost & productivity
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Cost&Productivity")
    If ThisWorkbook.Sheets("Cost & Productivity").Range("P17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("P17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C18").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("P17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C19").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("P17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C20").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Quality & technology data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Quality&Technology")
    If ThisWorkbook.Sheets("Quality & Technology").Range("P17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("P17").Value <=
ThisWorkbook.Sheets("Quality & Technology").Range("C18").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("P17").Value <=
ThisWorkbook.Sheets("Quality & Technology").Range("C19").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("P17").Value <=
ThisWorkbook.Sheets("Quality & Technology").Range("C20").Value Then
```

```
        .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Delivery data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Delivery")
    If ThisWorkbook.Sheets("Delivery (Service Level)").Range("P17").Value <= ThisWorkbook.Sheets("Delivery
(Service Level)").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("P17").Value <=
ThisWorkbook.Sheets("Delivery (Service Level)").Range("C18").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("P17").Value <=
ThisWorkbook.Sheets("Delivery (Service Level)").Range("C19").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("P17").Value <=
ThisWorkbook.Sheets("Delivery (Service Level)").Range("C20").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Time data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Time")
    If ThisWorkbook.Sheets("Time").Range("P17").Value <= ThisWorkbook.Sheets("Time").Range("C17").Value Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Time").Range("P17").Value <=
ThisWorkbook.Sheets("Time").Range("C18").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Time").Range("P17").Value <=
ThisWorkbook.Sheets("Time").Range("C19").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Time").Range("P17").Value <=
ThisWorkbook.Sheets("Time").Range("C20").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Waste data
With ThisWorkbook.Sheets("DASHBOARD").Shapes("Waste")
    If ThisWorkbook.Sheets("Waste").Range("P17").Value <= ThisWorkbook.Sheets("Waste").Range("C17").Value
Then
        .Fill.ForeColor.RGB = RGB(255, 0, 0) 'red
         ElseIf ThisWorkbook.Sheets("Waste").Range("P17").Value <=
ThisWorkbook.Sheets("Waste").Range("C18").Value Then
         .Fill.ForeColor.RGB = RGB(255, 165, 0) 'orange
         ElseIf ThisWorkbook.Sheets("Waste").Range("P17").Value <=
ThisWorkbook.Sheets("Waste").Range("C19").Value Then
         .Fill.ForeColor.RGB = RGB(255, 255, 0) 'yellow
         ElseIf ThisWorkbook.Sheets("Waste").Range("P17").Value <=
ThisWorkbook.Sheets("Waste").Range("C20").Value Then
         .Fill.ForeColor.RGB = RGB(0, 180, 0) 'green
    End If
End With
'Once the pyramid is coloured accordingly, the information regarding the number of categories that are with
status red, orange, yellow and green needs to be updated. This is the data for the speedometer
'First set the values to zero and then update them
'SECTION 4
ThisWorkbook.Sheets("DASHBOARD").Range("C33:C36") = 0
'Customer value data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Customer Value").Range("L17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Customer Value").Range("L17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Customer Value").Range("L17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Customer Value").Range("L17").Value <= ThisWorkbook.Sheets("Customer
Value").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'TCO data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Total Cost of Ownership").Range("P29").Value <= ThisWorkbook.Sheets("Total Cost
of Ownership").Range("C29").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("P29").Value <= ThisWorkbook.Sheets("Total
Cost of Ownership").Range("C30").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("P29").Value <= ThisWorkbook.Sheets("Total
Cost of Ownership").Range("C31").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Total Cost of Ownership").Range("P29").Value <= ThisWorkbook.Sheets("Total
Cost of Ownership").Range("C32").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Customer satisfaction
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Customer Satisfaction").Range("F17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C17").Value Then
```

```
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("F17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("F17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Customer Satisfaction").Range("F17").Value <= ThisWorkbook.Sheets("Customer
Satisfaction").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Flexibility data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C11").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C12").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C13").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Flexibility").Range("F11").Value <=
ThisWorkbook.Sheets("Flexibility").Range("C14").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Cost & productivity data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Cost & Productivity").Range("P17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("P17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("P17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Cost & Productivity").Range("P17").Value <= ThisWorkbook.Sheets("Cost &
Productivity").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Quality & technology data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Quality & Technology").Range("P17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("P17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("P17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Quality & Technology").Range("P17").Value <= ThisWorkbook.Sheets("Quality &
Technology").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Delivery data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Delivery (Service Level)").Range("P17").Value <= ThisWorkbook.Sheets("Delivery
(Service Level)").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("P17").Value <=
ThisWorkbook.Sheets("Delivery (Service Level)").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("P17").Value <=
ThisWorkbook.Sheets("Delivery (Service Level)").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Delivery (Service Level)").Range("P17").Value <=
ThisWorkbook.Sheets("Delivery (Service Level)").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Time data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Time").Range("P17").Value <= ThisWorkbook.Sheets("Time").Range("C17").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Time").Range("P17").Value <= ThisWorkbook.Sheets("Time").Range("C18").Value
Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Time").Range("P17").Value <= ThisWorkbook.Sheets("Time").Range("C19").Value
Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Time").Range("P17").Value <= ThisWorkbook.Sheets("Time").Range("C20").Value
Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
```

```
'Waste data
With ThisWorkbook.Sheets("DASHBOARD")
    If ThisWorkbook.Sheets("Waste").Range("P17").Value <= ThisWorkbook.Sheets("Waste").Range("C17").Value
Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C33") = ThisWorkbook.Sheets("DASHBOARD").Range("C33") + 1
    ElseIf ThisWorkbook.Sheets("Waste").Range("P17").Value <=
ThisWorkbook.Sheets("Waste").Range("C18").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C34") = ThisWorkbook.Sheets("DASHBOARD").Range("C34") + 1
    ElseIf ThisWorkbook.Sheets("Waste").Range("P17").Value <=
ThisWorkbook.Sheets("Waste").Range("C19").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C35") = ThisWorkbook.Sheets("DASHBOARD").Range("C35") + 1
    ElseIf ThisWorkbook.Sheets("Waste").Range("P17").Value <=
ThisWorkbook.Sheets("Waste").Range("C20").Value Then
        ThisWorkbook.Sheets("DASHBOARD").Range("C36") = ThisWorkbook.Sheets("DASHBOARD").Range("C36") + 1
End If
End With
'Following step is to create text boxes under each pyramid to indicate which one is related to the current
information and which one is from the past month or week
'SECTION 5
ActiveSheet.Shapes.AddTextbox(msoTextOrientationHorizontal, 370, 540, 370, 30).Name = "update info textbox"
ActiveSheet.Shapes("update info textbox").TextFrame.Characters.Text = "PREVIOUS MONTH/WEEK INFORMATION"
  With ActiveSheet.Shapes("update info textbox").TextFrame.Characters(Start:=1, Length:=50).Font
        .Name = "Arial"
        .FontStyle = "Regular"
        .Size = 18
        .Strikethrough = False
        .Superscript = False
        .Subscript = False
        .OutlineFont = False
        .Shadow = False
        .Underline = xlUnderlineStyleNone
        .ColorIndex = 41
   End With
ActiveSheet.Shapes.AddTextbox(msoTextOrientationHorizontal, 1045, 540, 250, 30).Name = "current info
textbox"
ActiveSheet.Shapes("current info textbox").TextFrame.Characters.Text = "CURRENT INFORMATION"
  With ActiveSheet.Shapes("current info textbox").TextFrame.Characters(Start:=1, Length:=50).Font
        .Name = "Arial"
        .FontStyle = "Regular"
        .Size = 18
        .Strikethrough = False
        .Superscript = False
        .Subscript = False
        .OutlineFont = False
        .Shadow = False
        .Underline = xlUnderlineStyleNone
        .ColorIndex = 41
   End With
End Sub
```

Macro 3:

ISO Year - Supporting macro that formats any data field into ISO year standard. The code for this macro is as follows:

```
Function IsoYear(d1)
'Transform any data field into iso year standard
Dim d2 As Long
d2 = DateSerial(Year(d1 - Weekday(d1 - 1) + 4), 1, 3)
IsoYear = Year(d2)
End Function
```

Macro 4:

ISO Week - Supporting macro that formats any data field into ISO week standard. The code is the following:

```
Function IsoWeek(d1)
'Transform any data field into iso week standard
Dim d2 As Long
d2 = DateSerial(Year(d1 - Weekday(d1 - 1) + 4), 1, 3)
IsoWeek = Int((d1 - d2 + Weekday(d2) + 5) / 7)
End Function
```

Macro 5:

Auto Open - This macro runs the update macro automatically once the dashboard document is opened. This provides users with the current information, avoiding the necessity of having to trigger the update pyramid color macro. Here is the code of the macro:

```
Sub Auto_Open()
'This macro will run automatically when the document is opened so the user can have immediate access to the
updated information
'This macro is composed of the two functions defined at the beginning of this module and the macro made to
update the pyramid info
    Call IsoYear(d1)
    Call IsoWeek(d1)
    Call Update_Pyramid_Colour
End Sub
```

Macro 6:

KPI Library - This is a very simple macro that directs the user to the KPI Library sheet. The code is the following:

```
Sub KPILibrary()
'Link to the KPI library
Application.Goto Sheets("KPI Library").Range("A1")
End Sub
```

Macro 7:

Dashboard - Also a very simple macro that directs the user to the dashboard sheet. It is present in all category worksheets and it is just a 'user friendly' feature. This is the code:

```
Sub DASHBOARD()
'Link to the dashboard
Application.Goto Sheets("DASHBOARD").Range("A1")
End Sub
```

Macro 8:

Shift Flexibility KPI Cells - Since the category of flexibility contains a new KPI, and there is no historical data regarding it, especially because it's a forecast, this macro needs to be triggered at the last day of every month. The macro will copy the information available about the performance of the KPI and paste it into the next column, allowing the new information from the new month to be available. This macro is triggered by the button located at the flexibility category named "click here at the last day of every month." This is the code of this macro:

```
Sub ShiftCells1KPIFlexibility()
'Since flexibility is a new KPI, and it is a forecast, the values will need to be transferred to a new
column at the last day of every month
'This macro copies the information of the current month and pastes it on the following column so that it can
give room for the new information of the next month
'ATENTION: this macro must run on the last day of every month
    Range("P3:P8").Copy
    ActiveSheet.Range("Q3:Q8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
    Range("O3:O8").Copy
    ActiveSheet.Range("P3:P8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
    Range("N3:N8").Copy
    ActiveSheet.Range("O3:O8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
    Range("M3:M8").Copy
    ActiveSheet.Range("N3:N8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
    Range("L3:L8").Copy
    ActiveSheet.Range("M3:M8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
    Range("K3:K8").Copy
    ActiveSheet.Range("L3:L8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
```

```
    Range("J3:J8").Copy
    ActiveSheet.Range("K3:K8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
    Range("I3:I8").Copy
    ActiveSheet.Range("J3:J8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
    Range("H3:H8").Copy
    ActiveSheet.Range("I3:I8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
    Range("G3:G8").Copy
    ActiveSheet.Range("H3:H8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
    Range("F3:F8").Copy
    ActiveSheet.Range("G3:G8").PasteSpecial xlPasteValues
    Application.CutCopyMode = False
End Sub
```

Macro 9:

Delete - The delete macro should be triggered after the comparison of the two pyramids regarding the past and current status of the pyramids. This macro allows the view of the dashboard to recover its initial aspect of the AS-IS pyramid. The button called "go back to as-is pyramid" will run this macro. The code is shown next:

```
Sub delete()
'This macro is to be used after running macro update past info pyramid colour and it provides the initial
dashboard view with the AS-IS pyramid
'First step is to delete the performance pyramid to the right of the dashboard and delete the textboxes
ActiveSheet.Shapes("Performance_Pyramid").Select
Selection.delete
ActiveSheet.Shapes("current info textbox").delete
ActiveSheet.Shapes("update info textbox").delete
'Then the update info macro is called
Call Update_Pyramid_Colour
End Sub
```

Appendix 10: TCO KPI Information

HOUR RATE	
Description	Hour rate (cost incurred by VDL ETG).
Target	0
Report Periodicity	Monthly
Unit of Measure	€
Formula	Hour Coverage/Total Hours
Lower & Middle Bound	L: M:
Owner	CoCoBo
Data Source	0

GROSS PROFIT	
Description	Net sales minus the cost of goods sold.
Target	0
Report Periodicity	Monthly
Unit of Measure	€
Formula	Net turnover - CoG
Lower & Middle Bound	L: M:
Owner	CoCoBo
Data Source	0

TURNOVER	
Description	Number of sales in that month.
Target	0
Report Periodicity	Monthly
Unit of Measure	I
Formula	Turnover
Lower & Middle Bound	L: M:
Owner	CoCoBo
Data Source	file://\\vdlgroep.local\etg\data\Eindhoven\

OVERALL MARGIN	
Description	Overall margin by month.
Target	> 10%
Report Periodicity	Monthly
Unit of Measure	%
Formula	(Turnover – Cost of Goods)/Turnover *100%
Lower & Middle Bound	L: 5% M: 10%
Owner	Jeroen Boekema
Data Source	file://\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\Margin Report ETG + Wallet Share.xlsx

Figure 45: TCO KPI Information

Appendix 11: Customer Satisfaction KPI Information

CUSTOMER RATINGS	
Description	How customers rate us based on QLTC aspects.
Target	99%
Report Periodicity	Quarterly
Unit of Measure	%
Formula	Overall average from all customer ratings available.
Lower & Middle Bound	L: 90% M: 95%
Owner	Jeroen Boekema
Data Source	file:///\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\Customer Ratings + QBR.xlsx

QUARTERLY BUSINESS REVIEWS	
Description	Assessing wether QBR are in place with customers.
Target	80%
Report Periodicity	Quarterly
Unit of Measure	%
Formula	(# QBRs in place / # customer accounts) *100%
Lower & Middle Bound	L: 70% M: 75%
Owner	Jeroen Boekema
Data Source	file:///\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\Customer Ratings + QBR.xlsx

Figure 46: Customer Satisfaction KPI Information

Appendix 12: Cost & Productivity and Quality & Technology KPI Information

HIGH LEVEL EFFICIENCY	
Description	Assessing efficiency by comparing wage hours with the realized direct hours
Target	65%
Report Periodicity	Monthly
Unit of Measure	%
Formula	Actual Parts Wage hours (FTE*40) / (VC Realized Direct Hours + NC Realized Direct Hours Indirectly Paid)*100%
Lower & Middle Bound	L: 45% M:55%
Owner	Michael van Vugt
Data Source	Manual Input from Michael

COST PRICE REDUCTION	
Description	Percentage of on target cost price reductions.
Target	90%
Report Periodicity	Monthly
Unit of Measure	%
Formula	(# targets met / # of total targets)*100%
Lower & Middle Bound	L: 70% M: 80%
Owner	Gerard van Wandeloo
Data Source	0

Figure 47: Cost & Productivity KPI Information

CUSTOMER COMPLAINTS	
Description	All customer complaints.
Target	60
Report Periodicity	Monthly
Unit of Measure	#
Formula	# of Complaints
Lower & Middle Bound	L: 84 M: 72
Owner	Gerard Hermkens
Data Source	..\..\..\..\Eindhoven\TQM\Reviews\Review PI Acht\PI_2015 Acht Share.xlsm

TECHNOLOGY ROADMAP	
Description	What percentage of targets from the technology roadmap have we met?
Target	0
Report Periodicity	Monthly
Unit of Measure	%
Formula	(# targets met in technology roadmap/ # total targets in technology roadmap)*100%
Lower & Middle Bound	L: M:
Owner	Edwin Leenders
Data Source	0

Figure 48: Quality & Technology KPI Information

Appendix 13: Delivery (Service Level) and Time KPI Information

CLIP	
Description	Assesses if VDL ETG delivers on confirmed delivery date. Sales CLIP
Target	95%
Report Periodicity	Weekly
Unit of Measure	%
Formula	(Sum of deliveries that were either too early, "ok", or 1 day too late in that week / total deliveries of that week)*100%
Lower & Middle Bound	L: 85% M: 90%
Owner	Program Manager
Data Source	file:///\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\CLIP Info.xlsm

RLIP	
Description	Assesses if VDL ETG delivers on requested delivery date. Sales RLIP
Target	90%
Report Periodicity	Weekly
Unit of Measure	%
Formula	(Sum of deliveries that were according to requested delivery date from customer in that week / total deliveries made in that week)*100%
Lower & Middle Bound	L: 70% M: 80%
Owner	Program Manager
Data Source	file:///\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\RLIP Info.xlsm

Figure 50: Delivery (Service Level) KPI Information

TIME TO MARKET	
Description	Length of time from product being conceived until it can be R4V.
Target	0
Report Periodicity	Weekly
Unit of Measure	Weeks
Formula	# Weeks from prodruct concept to R4V ready.
Lower & Middle Bound	L: M:
Owner	Edwin Leenders
Data Source	0

WORK IN PROGRESS	
Description	Anonymous WIP and project WIP
Target	0
Report Periodicity	Weekly
Unit of Measure	€
Formula	anonymous WIP + project WIP
Lower & Middle Bound	L: M:
Owner	John Langenhuysen
Data Source	file://\\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\WIP + Inventory.xlsx

Figure 49: Time KPI Information

Appendix 14: Waste KPI Information

INVENTORY	
Description	Anonymous inventory and project inventory
Target	0
Report Periodicity	Weekly
Unit of Measure	€
Formula	Anonymous inventory + project inventory
Lower & Middle Bound	L: M:
Owner	John Langenhuysen
Data Source	file://\\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\WIP + Inventory.xlsx

FIRST PASS YIELD	
Description	Number of POs that are not according to requirements the first time they are produced. This is for PARTS!
Target	90%
Report Periodicity	Weekly
Unit of Measure	%
Formula	Number of POs not according to requirements/ Total POs
Lower & Middle Bound	L: 80% M: 85%
Owner	Ivo Baijens
Data Source	file:///\\vdlgroep.local\etg\data\Eindhoven\TQM\MT Dashboard\Data\FPY.xlsx

Figure 51: Waste KPI Information