CHALMERS
UNIVERSITY OF TECHNOLOGY

Managing performance measurements in early production development phases

A case study at Volvo Cars

Master's thesis in Product Development and Production Engineering

JULIA HALLÉN
ALBIN LÖFGREN

Department of Technology Management and Economics
Division of Supply and Operations Management
CHALMERS UNIVERSITY OF TECHNOLOGY Gothenburg,
Sweden E2019:103

MASTER'S THESIS 2019:103

Managing performance measurements in early production development phases

A case study at Volvo Cars

JULIA HALLÉN
ALBIN LÖFGREN

Department of Technology Management and Economics
Division of Supply and Operations Management
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2019

Managing performance measurements in early production development phases
- A case study at Volvo Cars

JULIA HALLÉN
ALBIN LÖFGREN

Sponsor: Anders Granström, Volvo Cars Corporation, Body In White, Commodity
Supervisor: Anna Landström, Technology Management and Economics
Supervisor: Maria Ludvigsson, Volvo Cars Corporation, Body In White, Core
Examiner: Mats Winroth, Technology Management and Economics

Master's Thesis E2019:103
Technology Management and Economics
Division of Supply and Operations Management
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover: Volvo V60 Cross Country 2019. Retrieved from Volvo Cars Press Material:
`https://www.media.volvocars.com/global/en-gb/media/photos/list`

Gothenburg, Sweden 2019

Abstract

Performance Measurements, sometimes also called 'Key Performance Indicators', are becoming more and more frequently used in different kinds of operations, especially within manufacturing. The management of Performance Measures is sometimes referred to as 'Performance Measurement System', which is something practically all companies have in some form. Though, using Performance Measurements in early production development phases, before the actual production have started, is less common and little literature within this area currently exists.

The field that this thesis aims to investigate is the following; Management of Performance Measurements during early production development phases, with the purpose of providing one or several frameworks in order to secure alignment between the organisation, corporate strategies and Performance Measurements, including suggestions of how to improve present state.

This thesis has been performed through a single-case study at Volvo Cars Corporation in Gothenburg, Torslanda. The case has been carried out at the department 'Body In White', a function which develops the production processes and lines of the body plants. The study underwent three major phases: Orientational, Exploratory and Deliverables in order to fully understand the root cause problems and answer the defined research questions. The data gathering strategy was to conduct both a top-down and bottom-up analysis approach, which was mainly done through 26 semi-structured interviews at Torslanda as well as observations.

The thesis has resulted in an extensive definition of the Performance Measurement Systems in early production development phase, including purpose mapping and improvement areas, and solutions and interventions of identified problems. This includes a new suggestion of a Performance Measurement System and two frameworks: a model for connecting KPIs with Operational Excellence in early production development phases, and a model for KPI identification related to high-level strategies and objectives.

Developed solutions are expected to bring better clarity, understanding and an increased level of alignment for Performance Measurement Systems in early production development phases in the automotive industry.

Keywords: Performance Measurements, Performance Measurement System, KPI, Early Production Development, Operation Management, Manufacturing Strategy

Acknowledgements

At the start of this project there were a lot of questions and obscurity regarding how the thesis would proceed, how to delimit the research scope and what the real problem was. As the thesis was carried on, more and more questions got answered and the direction of this thesis became clear. Though, it would not have been possible to reach the finish line without the help of certain individuals.

We would like to send our biggest gratitude to our sponsor and supervisor at Volvo Cars, Anders Granström and Maria Ludvigsson, for enabling this master's thesis and for their confidence in us. Thanks for all support, engagement and interesting connections you have provided.

We would like to express our sincere gratitude towards our supervisor Anna Landström, which have helped us with valuable feedback and help, and our examiner Mats Winroth which have given us clear direction and guiding thoughts. Additionally, we thank you Mats for not retiring to early, letting us having you as our examiner.

Thanks to all the interviewees, for giving us your time to participate in the interviews and sharing of your ideas, knowledge and experience with us, as well as eating our fika, it has been a pleasure. Last, but not least, we would probably not be here finishing this thesis without the help and support from our families and friends, thank you so much!

Gothenburg, June 2019 Julia Hallén & Albin Löfgren

Terminology

The following terminology and abbreviations has been used in the report, tables and appendix.

BIW	Body In White
E	Engineers
I40	Industry 4.0
KPI	Key Performance Indicator
KPI-E	Key Performance Indicator Effectiveness
Lean	Lean production
M	Managers
ME	Manufacturing Engineering
M&L	Manufacturing and Logistic
PDCA	Plan-Do-Check-Act cycle
PM	Performance Measurement
PMs	Performance Measurements
PMS	Performance Measurement System
PRM	Program Manager
PSR	Project Status Report
P&Q	Product & Quality
Op Dev	Operational Development
R&D	Research & Design
SM	System Manufacturing
TM	Top Management Manufacturing Engineering and Manufacturing & Logistics
TM-BIW	Top Management Body In White
TM-P	Top Management Plant
TPS	Toyota Production System
TQM	Total Quality Management
VPDS	Volvo Car's Product Development System

Contents

List of Figures

List of Tables

1
Introduction

This chapter describes the background and problem analysis of this thesis, including aim, research questions, delimitations and related case background.

1.1 Background

Designing, implementing and using measurement data in a correct way is essential when it comes to achieve company objectives, especially within the areas of process performance control and improvement (Franceschini et al. 2007, 7). Performance Measurements (PMs) refers to the measures that is taken on order to assess company performance, measures that sometimes also are called Key Performance Indicators (KPIs) (Almström et al. 2017). According to Srimai et al. (2011) the areas where PMs are being used have increased from being used only for static and financial performance measures, to be more and more applied into strategic systems. The management of these PMs, and the related alignment of strategy, is often referred to as "Performance Measurement Systems" (PMS) (Ante et al. 2018).

1.1.1 Performance Measurement Systems: An overview

A Performance Measurement System is a system which overall purpose is (Frolick & Ariyachandra 2006) to monitor production and business performance and thus implement overall corporate strategies and objectives (Almström et al. 2017). Some examples of definitions of such a system are:

> ”A performance measurement system is responsible for coordinating indicators across the various functions, and for aligning the indicators from the strategic (top management) to the operational (floor/purchasing/executing context) levels” (Franceschini et al. 2007, 13)

> ”An information system based on a holistic (multi-dimensional/balanced/integrated) view of organisational performance, as conceptualised through a performance measurement model, in support of executive decision making and strategic management, by producing information in a manner that reflects the performance logic (determinants/results) of the organisation” (Marchand & Raymond 2018)

Thus, a PMS can be said to consist of two main parts:

(1) Performance Measurements (PMs):
- definition of proper PMs
- PM usage and management from a system perspective

(2) Strategy Alignment:
- connection between corporate strategy and the PMs

1.1.2 Early development phases: Enabling Indicators

In a manufacturing context PMs are mainly used for the measurement of manufacturing operations management, i.e. the level of performance of quality, efficiency, inventory, compliance etc. (ISO/DIS:22400-1 2013) in running production. Though, previous research have highlighted that an increased understanding for using PMs at different levels in manufacturing companies is needed in order to increase the understanding of which type, topic and frequency and updating of indicators that are suitable for the different level and/or function (Landström, Almström & Winroth 2016). One of these levels are during production planning and early production development, phases before the actual production launch have started. Very little research have been conducted within this field (Wiktorsson et al. 2018), and it is continuously difficult for companies to implement best practise routines.

Some research have categorized the concept of PMs early production development phases as ”enabling indicators”, referring to indicators that enables future, desired performance (Wiktorsson et al. 2018). Further, these kinds of PMs have been emphasized as an interesting future area of research, as they possess potential of linking Product Development processes to the Production Development processes, in order to align early phase requirements engineering as well as financial business cost models (Wiktorsson et al. 2018). The author emphasize that there today exists need of principles and schemes for developing relevant sets of PMs during early production development phases, as well as studies on detailed development of the concept and implementation and evaluation schemes.

1.2 Purpose & aim

This thesis aims to investigate how PMs, and PM Systems, are and should be managed during early production development phases. Considering the context of ”enabling indicators” and lack of current research within this area, the purpose of this master thesis is formulated to be the following:

The purpose of this master thesis is to investigate and evaluate how Performance Measurement Systems are defined and managed during early production development phases in the automotive industry, in order to develop and provide an integrated framework to ensure alignment between manufacturing strategy, corporate goals, objectives and Performance Measurements. Through this, the aim is to guide the department within production development towards taking decisions in line with company vision through the project phases.

This issue will be investigated through a single case study at Volvo Cars Corporation (Volvo Cars) at one of their production development business areas.

1.3 Problem analysis

As global competition between car manufacturers rises, there exists a big need for car manufacturers to stay ahead of the performance curve. The globalization has been described by Sirkin et al. (2008) as the issue of "competing with everyone from everywhere for everything". As manufacturing plays an important role in a business's value chain (Mercadal 2019), it is important to ensure alignment between the performance measurement system used in manufacturing during production planning phase and the corporate strategic goals.

Considering the immaturity of today's current state of PMs in early production development phases, there can be defined a potential gap between current, and possible improved state. Having one or potentially several frameworks, operational improvement can be linked towards Performance Measurements and through this form a sustainable Performance Measurement System.

The relationship between the two states, the gap and the framework is illustrated by figure 1.1.

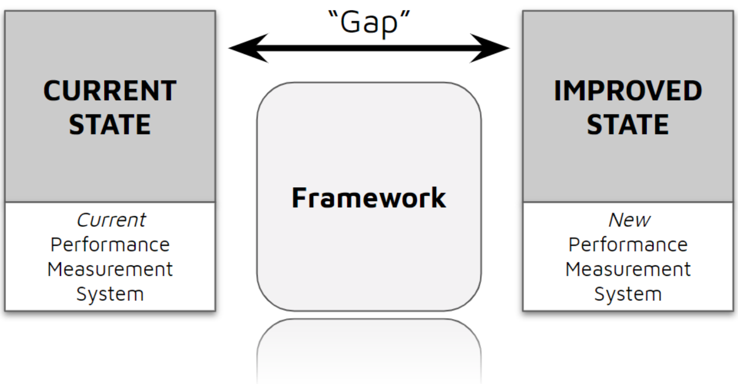


Figure 1.1: The problem illustrated

In question of approaching the formulated purpose and aim, it is essential to identify what the *real* problem is, the root causes to the present state's potential pitfalls. As seen in figure 1.2, a model based on Lean Production problem-solving techniques can be used for this purpose. This is done by looking at the situation from a wide view in the beginning, until the problem is fully defined, and further narrowing it down through analysis until the root-causes are defined. First after that can potential solutions can be identified and/or developed, evaluated and finally implemented.

Thus, this thesis intends to have a problem-oriented research approach, in order to find and solve issues related to current management.

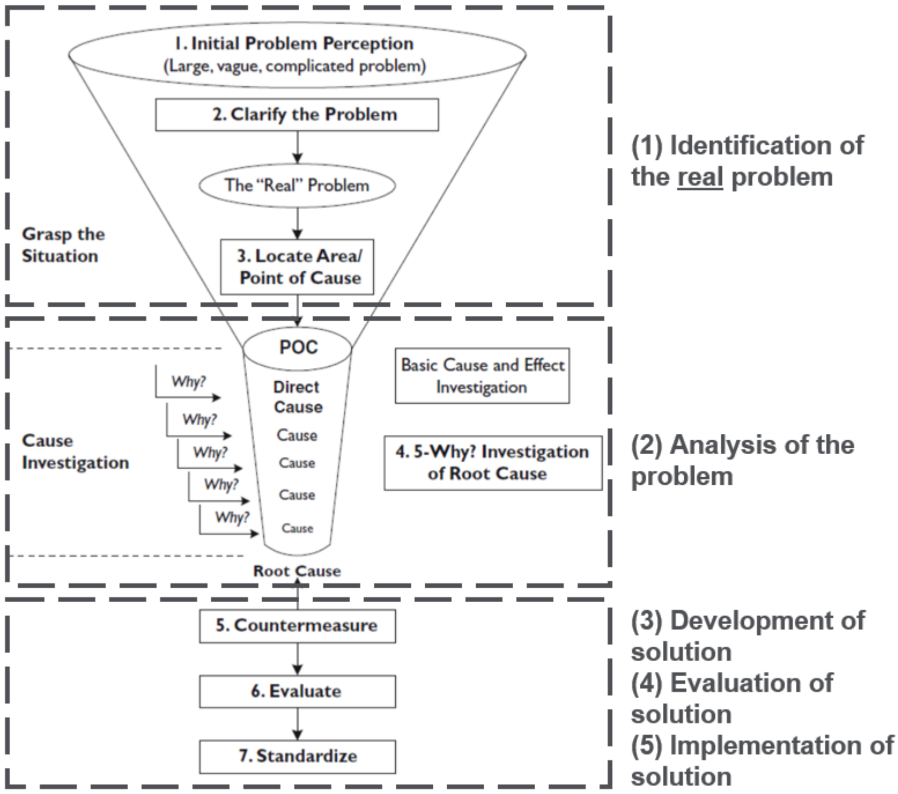


Figure 1.2: Approaching the problem: a model inspired by lean problem-solving practices (Liker 2004)

1.4 Research questions and outcomes

Following from the problem analysis, this master thesis aims to answer the following research questions:

RQ1: How is Performance Measurement Systems during early production development phase defined and managed?

RQ2: How can Performance Measurement System during early production development phase be improved?

RQ3: What should a framework look like that could help the transition between current to improved state?

The outcome of the analysis of the research questions targets to develop one or several framework which provides guidelines on how to achieve and sustain an efficient Performance Measurement System for actors that works within early production development phases within the automotive industry.

1.5 Case Background

The implementation of Operational Excellence Programs has since many years back been a popular subject along industrial businesses, and is nowadays considered as a "must have", rather than something to strive for (Nolan & Anderson 2015). Volvo Cars has, since a couple of years back, prepared for a similar initiative which involves a lean transformation of the Manufacturing and Logistics (M&L) department. The transformation is global and aims to accomplish a Best-In-Class Operational Excellence organization, including achievement of five predefined targets which should be reached by year 2020.

1.5.1 Introduction of Performance Measurements

As part of this transformation a number of PMs was developed, which could help the M&L organization to more easily visualize and quantify current strategies and objectives, and thus quicker reach a higher level of operational excellence. Responsible for the development and management of these PMs is the separate business units under M&L. In a manufacturing context this refers to the Manufacturing Engineering (ME) unit, the unit which is globally responsible for the design and execution of Volvo Cars different production plants. Further, the PMs are divided between the ME sub-units Stamping, Body In White, Paint and Final Assembly, and are in other words unique for each department (as each sub-unit has developed their own set of PMs). In this master thesis it is Body In White's Performance Measurement System that has been studied and evaluated.

1.5.2 Volvo Cars and Manufacturing Engineering BIW

Volvo Cars is a global car manufacturer with headquater in Gothenburg, Sweden and with plants in Sweden (Torslanda/Gothenburg, Skövde and Olofström), Belgium (Gent), China (Chendu, Zhangjiakou, Daqing, Luqiao) and USA (Charleston). Volvo Cars also have two knock-down plants in Malaysia (Kuala Lumpor) and India (Bengaluru).

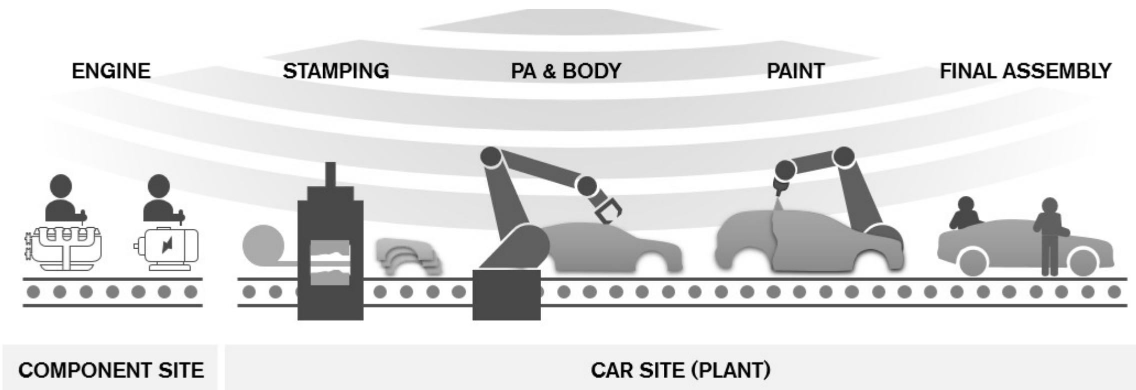


Figure 1.3: The production flow at Volvo Cars, Torslanda

Manufacturing Engineering Body In White (hereafter only referred to as ”BIW”) is one of the five production planning units where new layouts and processes are developed, holding a coordinating role between design (R&D) and production, securing that future products are possible to manufacture. As seen in figure 1.3, BIW is responsible for the assembly of ’PA and Body’, indicating the assemble process of the Body (bodystructure, upperbody, underbody, hang on parts) and subassemblies (PA), having an inflow of parts from the Stamping plant and an outflow of parts to Paint plant.

Like many other companies, Volvo Cars have historically not used PMs during production planning phases. Though, as a result from the Lean transformation, a couple of PMs have been developed. Nevertheless, today’s usage of the PMs is still in a rather young and immature state, and is suspected to bear areas of improvements.

1.6 Delimitations

This thesis will be limited to a single case study, investigating the Performance Measurement System for the Body In White unit at Manufacturing Engineering for Volvo Cars Corporation at Torslanda, Gothenburg. Continuously, the study is conducted within the constraints of a production planning and manufacturing engineering phase, i.e. the early production development phases for body shops[1].

[1]Early production development phases refers to the phases where advanced engineering and production preparation are conducted (Wiktorsson et al. 2018)

2

Method

This chapter describes the selected research strategy and research methods of the thesis.

2.1 Research strategy

In order to be able to answer the research questions it is important to consider a well-planned, structured research strategy. A research strategy describes the general approach on how the research is conducted, depending on the nature of the research questions.

2.1.1 Case study context

In this thesis one of the prerequisites was to perform a case study at Volvo Cars, and thus elaborate a suitable research strategy for that environment. Yin (1994) states that a case study is an empirical inquiry that ”investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident”. Also, according to Yin (1994), a case study is appropriate to use as the preferred research strategy when investigating more explanatory research questions (with focus on "how" and "why").

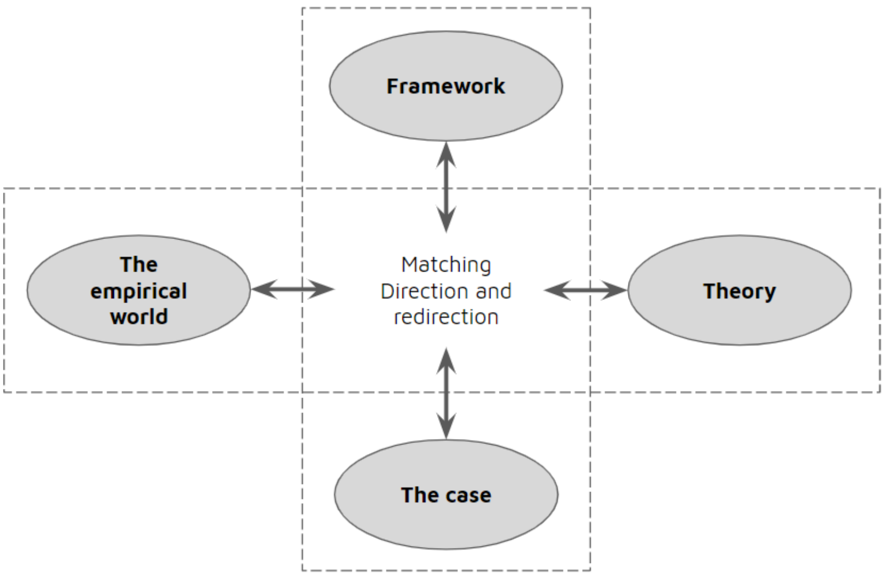


Figure 2.1: Systematic combining according to Dubois & Gadde (2007)

When performing a case study it is appropriate to use *systematic combining* to get in-depth insights of empirical phenomena (Dubois & Gadde 2007) and thus triangulate the problem in an efficient way, as seen in figure 2.1. This method deals with two main concepts: matching, direction and redirection. Matching refers to going back and forth between framework, data sources and analysis, and direction and redirection to the impact made by different sources of data and the methods used for collection of data.

Further, one of the cornerstones of the model is an *evolving framework*. The authors suggests that a tight and evolving framework should be used, indicating that a prestructured, predefined framework (based upon research) is evolved during the study, changed by empirical observations.

Considering the context of the thesis and related research questions, the systematic combining approach was selected to stand as the basic research strategy for the project.

2.1.2 Research phases

According to Graziano & Raulin (2014) a research study includes seven different phases:

1. Idea-Generating phase: Identify a topic of interest to study.

2. Problem-Definition Phase: Refine the vague and general idea(s) generated in the previous step.

3. Procedures-Design Phase: Decide on the specific procedures to be used in the gathering and analysis of data.

4. Observation Phase: Use the procedures devised in the previous step to collect your observations.

5. Data Analysis Phase: Analyze the data.

6. Interpretation Phase: Compare your results with the results predicted based on your theory.

7. Communication Phase: Prepare a written or oral report for publication of the results and conclusions.

Supported by these points, the thesis has been conducted through three main phases; an *orientational* phase, where a deeper problem analysis was performed to investigate the problem context (and subsequently form the researcher questions), thus supporting point (1) and (2), an *exploratory* phase, where the case study together with the theoretical framework was performed and analyzed, thus supporting point

(3), (4) and (5), and finally the *deliverables* phase, where the framework was created and conclusions could be drawn as well as recommendations for the future, thus supporting point (6) and (7). The project phases are illustrated in figure 2.2.

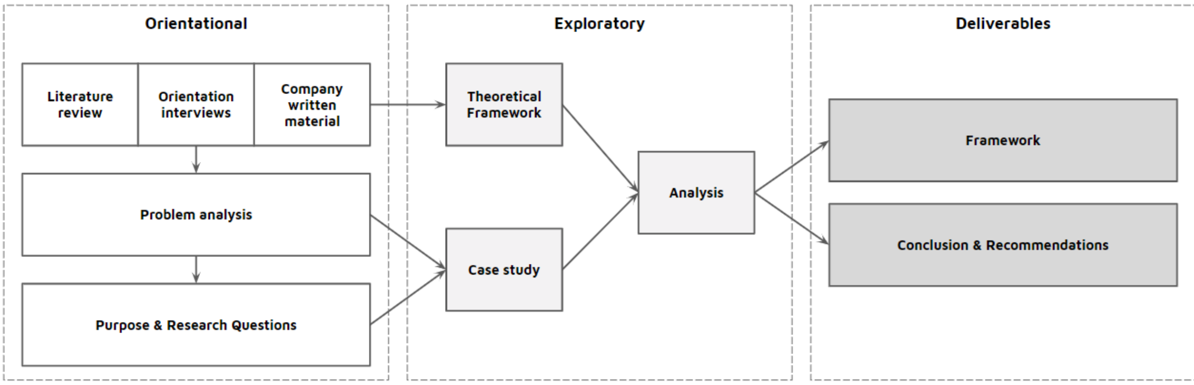


Figure 2.2: Overview of project phases

After the orientational phase, the three research questions was formed. Point three, the Procedure-Design Phase, resulted in a three-step framework that showed necessary steps in order to provide related answers. Figure 2.3 shows these steps and associated activities.

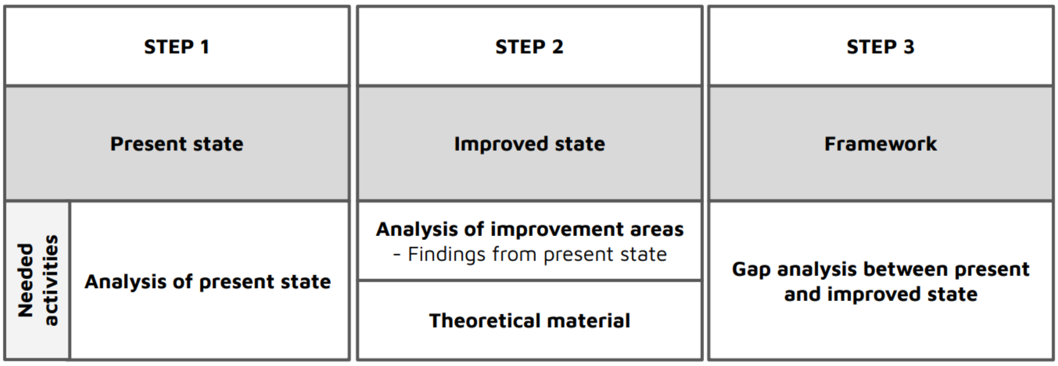


Figure 2.3: Overview of the steps in order to answer the research questions

Based on these steps, the data collection and analysis methods could be decided.

2.2 Data collection

In the following section the data collection method is described.

2.2.1 Data collection approach

Bryman et al. (2014) states that there exists two main approaches to conduct business research: quantitative research and qualitative research. Quantitative research tends to use an deductive approach which focus on testing existing theories whereas qualitative research on the other hand tends to use an inductive approach which focus more on generating theories. Quantitative and qualitative research can be combined into mixed research methods, which is very popular in business and management research. Due to the exploratory nature of the research questions it was decided that only a qualitative research approach would be performed. This, together with the systematic combining described above, enables a combination of both a deductive and inductive approach. Through this the framework and future recommendations could be evolved through an iterative process where theory supports on one hand, and the case on the other hand.

2.2.2 Orientational interviews

The Idea-Generation and Problem-Definition phases can also be described in terms of ”orientational interviews”. According to Keizer & Kempen (2006), this includes a perspective and risk analysis, at a time when any risks and possibilities that come to light can still be influenced. The idea is not that the result should evolve imperceptible in-depth research, but rather to get valuable information and insights about stakeholder interests, interests and possible conflicts, as early as possible. The authors recommends that between five to ten orientational interviews are conducted before the actual research starts. Below in table 2.1 follows a summation of the performed orientational interviews:

Table 2.1: Interviewees: Orientational phase

Title	No.	Department
Engineer	2	Volvo Cars, BIW
Manager	3	Volvo Cars, BIW
Expert (Professor)	1	Chalmers Technical University

2.2.3 Exploratory Interviews

Sreejesh et al. (2014) states that there exists three ways to conduct a qualitative research study:

1. Depths Interviews - Interviews with individuals
2. Focus groups - Discussion with a group of individuals
3. Projective Techniques - An unstructured form of questioning that inspires the respondents to express their underlying motivations, beliefs and/or attitudes regarding the certain issue

In order to assess information about current state and possible improvement areas, several *depth interviews* was conducted, as they are having the advantage of determining the motivations and resistance of certain attributes, without being biased by other individuals’ opinions (Sreejesh et al. 2014). The author describes that there exists three different types of depth interviews: (1) Unstructured interviews, (2) Semi-structured interviews, and (3) Standardized open-ended interviews.

Semi-structured interviews are having the advantage of being flexible at the same time as the interviewer ensures that he keeps the interview limited to the topics that are essential to the research (Sreejesh et al. 2014)(Bryman et al. 2014). Given the research questions, this approach was considered most appropriate, and thus selected as one of the main data collection methods.

In order to be able to answer the research questions, the following areas was identified as important to answer: *Strategies and Objectives*, *Work procedures*, *KPIs: Definition* and *PMS: Processes and management*. In order to select a valid group of interviewees, a relationship matrix was developed to identify needed stakeholders, according to figure 2.4.

Investigation Areas	*Purpose of investigation*	**M&L**	**ME**	**BIW**				**Plant**
		Top Management	Top Management	Top Management	Program Managers	Managers	Engineers	Top Management
Strategies & Objectives	Definition	X	X					X
	Perception			X	X	X	X	
Work procedures	Definition			X	X	X	X	
KPIs: Definition	Purpose	X	X	X				
	Definition					X	X	
	Perception				X			
PMS: Processes & management	Definition			X	X	X	X	
	Perception					X	X	
	Industry 4.0	X	X	X	X	X	X	X

Figure 2.4: Relation between investigation areas and interview agents

As seen above in figure 2.4, this resulted in 7 different stakeholder groups that would be of interest for the research. Further, deeper investigations showed that this will affect people in 9 different areas (departments or teams) as seen in table 2.2, within Volvo Cars, on various levels. Table 2.2 also shows the full list of the different interviewees including title, number of interviewees per title (No.), department/team and level.

In order to make the handling of the data from the interviewees easier, in table 2.2 and the rest of the report, abbreviations has been used as well as the interviewees has been grouped together to form the following stakeholders:

- Top Management ME/M&L = TM
- Top Management BIW = TM-BIW
- Top Management Plant = TM-P
- Program Manager = PRM
- Managers = M
- Engineers = E
- Operational Development = Op Dev
- System Manufacturing = SM

Table 2.2: Interviewees at Volvo Cars

Stakeholder	Title	No.	Department/Team	Level
TM	Vice President	1	Quality & Op Dev	M&L
	Director	1	Business Office	M&L
	Vice President	1	Manufacturing Engineering	M&L
	Senior Director	1	Op Dev and Business Support	ME
TM-BIW	Senior Director	1	Body in White	ME
	Director	1	Commodity	BIW
TM-P	Vice President	1	Plant Torslanda	Plant
	Senior Advisor	1	Plant Torslanda	Plant
PRM	Program Manager	1	Body in White (BIW)	ME
M	Manager	1	Core	BIW
	Manager	6	Commodity	BIW
E	SM Engineer	4	Commodity	BIW
	SM Engineer	2	Core	BIW
	Process Engineer	3	Commodity	BIW
	Op Dev Engineer	1	Core	BIW
TOTAL		**26**		

In total 26 interviews was performed with Volvo Cars employees from the plants in Torslanda and Olofström. Interviews with employees from Olofström was included because the tight connection between BIW and the operations at Olofström. Each interview took approximately one hour to perform.

2.2.4 Interview Questions

The interview questions, see Appendix A, was designed through a top-down and bottom-up analysis approach inspired by Landström, Almström, Winroth, Andersson, Windmark, Shabazi, Wiktorsson, Kurdve, Zachrisson, Ericson Öberg & Myrelid (2016), where the data collection is divided into two main parts with the aim to study the differences and similarities between the management view of the PMs, and the actual PMS. According to the authors, this method is based upon a list developed by Neely et al. (1997), providing a time-efficient method to get a snapshot of the present state PMS. Further, based on the KPI lifecycle developed by Almström et al. (2017) (see chapter 3.1), more questions was developed to fully cover the present state of the PMS.

2.2.5 Observations

To further support the data collection, *Participation Observations* were conducted. In this process the researchers are involved in the day-to-day activities of the individuals and groups in order to develop a scientific understanding (Sreejesh et al. 2014). This was considered important in order to get valuable insights about the case study context.

The observations included participation on the following events:

- Participation on Manufacturing Engineering Strategy Days (information about current strategies)
- Participation on BIW Commodity Townhall meeting (information about the new organizational structure)
- Participation on internal BIW group meetings (information about current organisational status)

2.3 Data analysis

This section describes the chosen methods used in order to analyze the data gathered from the data collection.

2.3.1 Analysis approach

In this thesis, the analysis was supported by a breakdown of the problems through the KPI lifecycle's phases; Design, Implement, Use and Revise, including alignment of manufacturing strategy. Further, a dimension including future technology/Industry 4.0 was also included in order to take potential future implications into consideration.

The aim was to identify the main problems related to current PMS as described in section 1.3, in order to identify the purposes of PMs in early production development phases, as well as gaps, problems and improvement areas, and continuously be able to find suitable solutions. The study consist of several steps of data analysis. The main analysis is based on a two-step approach where the raw data is interpreted in terms of facts, problems and needs. This analysis consists of:

1. KJ analysis
2. Problem and Needs analysis

To analyze possible improved state and a suitable framework, several gap analysis was conducted within the field of PM apprehensions and identified problem areas from the analysis of present state. Further, three methods presented below was used to help conclude the main findings and find suitable strategies and solutions.

1. IDEF0 analysis
2. SWOT analysis
3. TOWS analysis

These analysis methods are describes more elaborately below.

2.3.2 KJ Analysis

The KJ Analysis, sometimes called ”Affinity Diagram analysis”, is a Japanese management technique developed by the ethnologist Jiro Kawakita that helps develop insight into themes and relationships. It assists with drilling high-level issues to a more detailed set of common statements, helping to group and organize problems (Scupin 1997), and a common tool in total quality management (TQM) (Karl 2003).

According to Karl (2003) the method is suitable for multi-faceted problems and problems which involves disparate interests and perspectives, thus suitable to the thesis' aim. The method includes the following steps:

1. Pose question(s)
2. Gather statement of facts
3. Arrange facts in groups
4. Create headers for groups
5. Arrange groups and show relationships
6. Write concluding statement and reflect

2.3.3 Problems and Needs Analysis

Based on a problem-development and requirement management approach by Ulrich & Eppinger (2012), the identified problem groups and statements from the KJ Analysis was interpreted and organised in terms of stakeholder needs. This list can be found in Appendix B.

The method aims to ensure that the ”product” - or the solution in this situation - is focused on customer needs, and that a common understanding of customer needs are developed among the ”development team” (in this situation: the thesis' authors) (Ulrich & Eppinger 2012). The process follows the following steps:

1. Gather raw data (in this case, groups and data from the KJ Analysis)
2. Interpret the data in terms of customer needs
3. Organize the needs into a hierarchy of primary and secondary needs
4. Establish the relative importance of the needs

2.3.4 IDEF0 Analysis

IDEF0 is a powerful and simple process mapping technique developed by the US Air Force, which aims to relate an activity with inputs and outputs (Holweg et al. 2018). According to Holweg et al. (2018) the very foundation of operations management is the process, and this method has been used in order to help relate the PMs purposes with the organisation's context. For each process there is a transformation of some sort. According to Fülscher & Powell (1999) there are connections to the rectangles/processes four different sides made of arrows that represent the following: Inputs, Controls, Resources and lastly Outputs. A visualization of IDEF0 can be seen in figure 2.5.

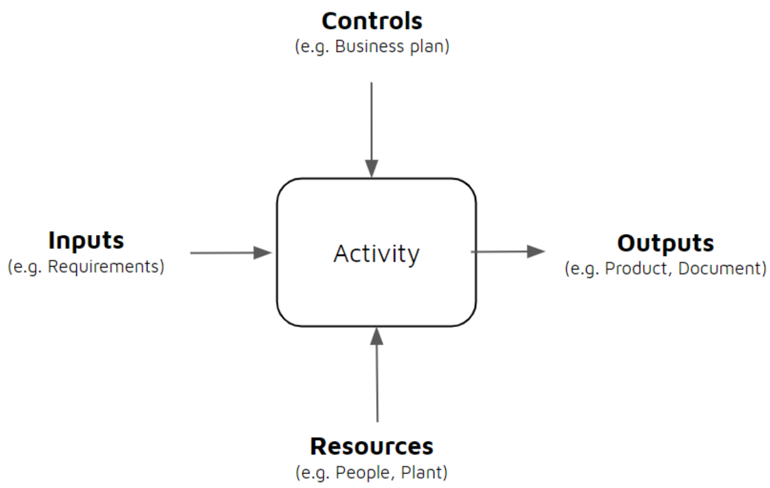


Figure 2.5: Process mapping method IDEF0, level 0 (Fülscher & Powell 1999)

2.3.5 SWOT and TOWS Analysis

A SWOT Analysis is conducted in order to identify strengths, weaknesses, opportunities and threats of the, and is a good starting point for the analysis of operational resources (Slack & Lewis 2010).

The TOWS-analysis on the other hand uses the results from the SWOT-analysis in order to formulate strategies for matching the company's external environment (threats and opportunities) with its internal environment (weaknesses and strengths) (Weihrich 1982).

2.3.6 Full research design

The full process of how the thesis was performed to answer the three research questions, through above mentioned methods, can be seen through the network diagram in figure 2.6 where each activity are presented with related outcomes.

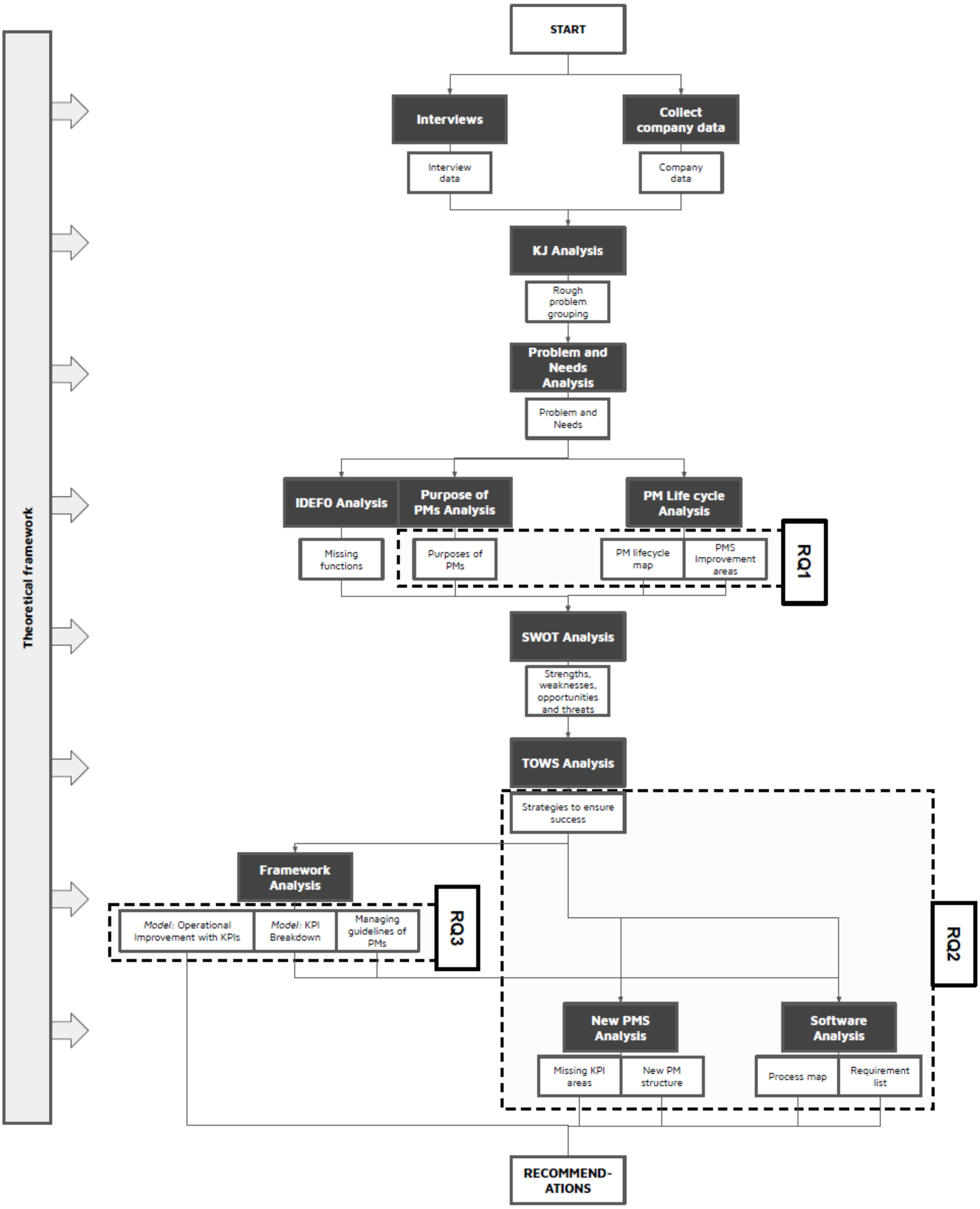


Figure 2.6: Detailed illustration of conducted activities and related outcomes in relation to the research questions

2.4 Societal, ethical and ecological aspects

According Bryman & Bell (2011) it is important to consider ethical aspects, such as how to treat people or which activities to engage in, when conducting research. Bryman & Bell (2011) also states that there are four ethical principles to consider when conducting business research:

- lack of informed consent,
- deception,
- harm to participants, and
- invasion of privacy.

Therefore, before every conducted interview or interacting research events, the purpose of the study was stated and explained. No one was forced to take part in interviews or to answer certain research questions. Furthermore, the thesis has taken the societal aspects, such as local norms, customs and rules at Volvo Cars, into consideration when conducting the study. Finally, this thesis aims to provide guidelines of how to create a sustainable PMS, with respect to both societal, ethical and ecological aspects in an integrated manner.

3
Theoretical framework

This chapter describes the theoretical framework which the thesis is based upon. The chapter is divided in five parts, including theory about (1) Performance Measurement Systems, (2) Key Performance Indicators, (3) Critical success factors and common pitfalls for point one and two, (4) Operations Management and Strategy, and (5) Industry 4.0.

3.1 Performance Measurement Systems

Measuring business performance effectively is vital for executive management in order to ensure improvement in operational effectiveness and a sustainable growth of profits (Gupta 2006, XV). Figure 3.1 below describes how a Performance Measurement System (PMS) can be described, defined in terms of the KPI lifecycle aligned with the company's manufacturing strategy and objectives.

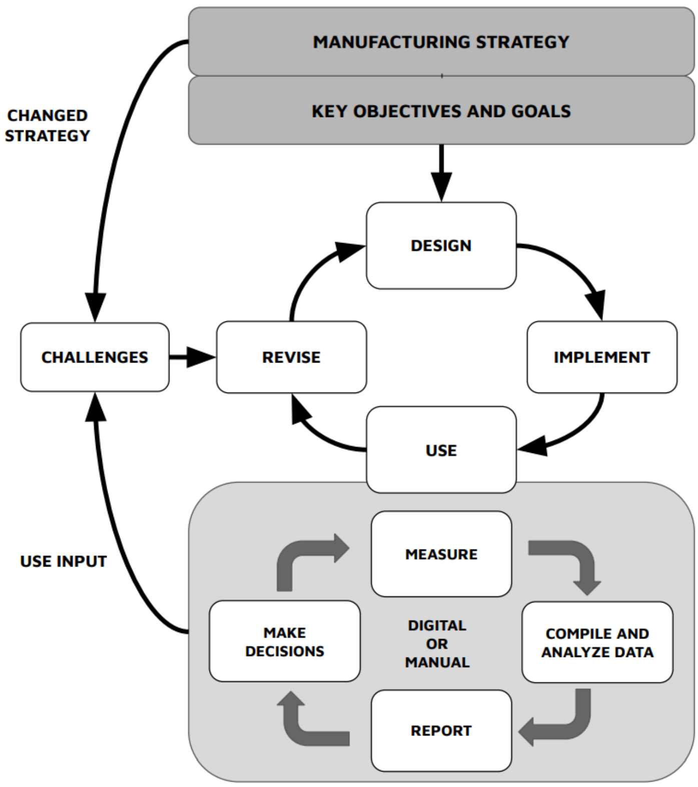


Figure 3.1: The KPI lifecycle (Almström et al. 2017)

The KPI lifecycle is defined by its four phases, *Design*, where the KPIs are defined, *Implement*, where the KPIs are incorporated into the business, *Use*, where the data collection, reporting and analyzing of the KPIs are performed, and *Revise* where the KPIs are evaluated and possibly added/removed (Almström et al. 2017).

One way of putting a PMS into context is by considering it in relation to other PMS', as seen in figure 3.2. According to the authors of this model (Bititci et al. 1997), a company could in other words have several systems where performance measurements are used, with different aims and purposes. As seen in the figure, the systems are related to an integrity aspect approach and a deployment aspect approach. The integrity aspect deals with "the ability of the performance measurement system to promote integration between various areas of the business", and the deployment aspect with "the deployment of business objectives and policies throughout the hierarchical structure of the organization".

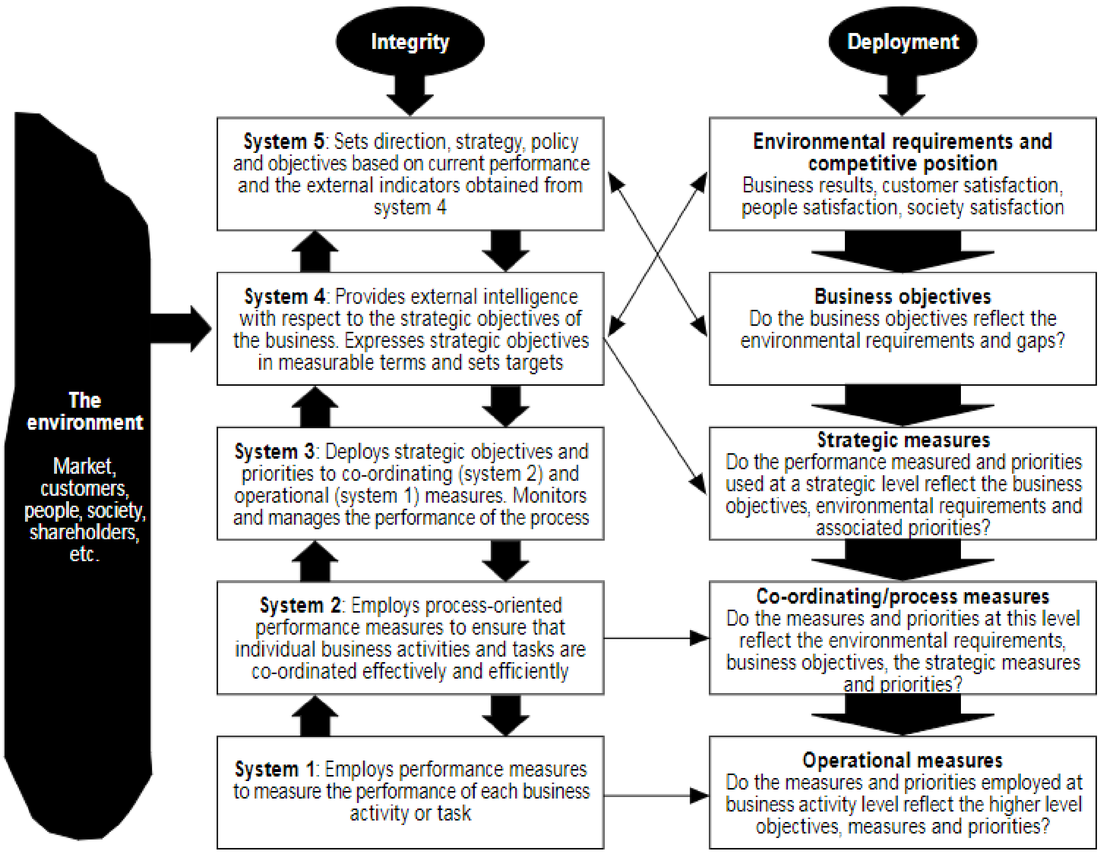


Figure 3.2: A reference model for integrated performance measurement systems (Bititci et al. 1997)

The usage of KPIs during early production development phases would, using this reference model, refer to system 1, 2 and possibly 3, depending on the specific company and situation.

3.2 Key Performance Indicators (KPIs)

Key Performance Indicators, also called KPIs, are according to ISO standard 22400-1, ”a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization”. A KPI is characterized by information regarding its content (quantitative elements with specific units of measure) and context (verifiable list of conditions that needs to be met, or in other words its relation to the PMS) (ISO/DIS:22400-1 2013).

3.2.1 The KPI structure

There exists three main categories of KPIs; (1) improvement KPIs, (2) reporting KPIs, and (3) controlling KPIs (Almström et al. 2017). A single KPI can, depending on the need of the use, reflect one or more of these categories. Further, a KPI can be of ”lagging” or ”leading” type. A lagging KPI is typically an output oriented result, whereas a leading indicator is input oriented, affecting the lagging KPI (Wiktorsson et al. 2018). Further, the value of a KPI is defined by primarily six unit-of-measure types (ISO/DIS:22400-1 2013):

- Ratio - a fraction between two elements of the same unit-of-measure
- Utilization - a fraction between two elements where both has time as unit-of-measure
- Efficiency (internal measure) - the effort in relation to the usage
- Effectiveness (external measure) - the relation between between planned to actual value
- Rate - a fraction between two elements of different unit-of-measure, where the denominator is time
- Capability Index - a measure of the fit of the capability in relation to the assigned task

A KPI is built upon elements, the measurements that are of relevance for calculating the KPI value.

3.2.2 Criteria of KPIs

When designing a KPI it is important to consider certain KPI criteria, in order to make sure that the KPI achieves a high level a validity. Below follows a set of the most common KPI criteria:

1. **Accessible** - the level of ease to obtain correct and complete KPI measurements (ISO/DIS:22400-1 2013)
2. **Achievable** - the team responsible for the KPI is able to influence the value of the KPI given available resources (Almström et al. 2017)(ISO/DIS:22400-1 2013)
3. **Aligned** - both vertically (the degree to which a KPI is able to affect a higher-level KPI) and horizontally (the degree to which a KPI is aligned with KPI sets in same-level operations in the corporate hierarchy) (ISO/DIS:22400-1 2013)

4. **Balanced** - the degree to which a KPI is balanced within its chosen set of KPIs (ISO/DIS:22400-1 2013)
5. **Calculable** - correctness and completeness of the formula required to calculate the KPI value (ISO/DIS:22400-1 2013)
6. **Comparable** - historic data is maintained and available for comparison to current values (ISO/DIS:22400-1 2013)
7. **Consistent** - high significance even as time goes by (Neely et al. 1997)
8. **Documented** - documented instructions for implementation of a KPI that is correct, complete, and unambiguous, including instructions on how to compute the KPI, what measurements are necessary for its computation, and what actions to take for different KPI values (ISO/DIS:22400-1 2013)
9. **Feedback oriented** - able to provide fast feedback (Neely et al. 1997)
10. **Improvement related** - related to improvements (Neely et al. 1997)
11. **Information providing** - able to give information about the current situation (Neely et al. 1997)
12. **Predictive** - high degree of the KPI to predict harmful events (ISO/DIS:22400-1 2013)
13. **Quality of data** - high level of fidility between the reported KPI value and its true value (ISO/DIS:22400-1 2013)(Neely et al. 1997)(Almström et al. 2017)
14. **Quantifiable** - the KPI can be stated numerically and precisely (ISO/DIS:22400-1 2013)(Neely et al. 1997)
15. **Fraction** - KPIs as ratios/fractions rather than absolute numbers (Neely et al. 1997)
16. **Relevant** - applicable to the success of the organization (Neely et al. 1997)(Almström et al. 2017)
17. **Simple** - easy to understand and have a simple consistent format (Neely et al. 1997)
18. **Specific** - possess a distinct purpose for the business (Neely et al. 1997)(Almström et al. 2017)
19. **Strategy derived** - close connection to strategy (Neely et al. 1997)
20. **Support** - the willingness of a team/management to choose and support appropriate KPIs, acheivement of KPI targets, and perform the tasks necessary to improve target KPIs (ISO/DIS:22400-1 2013)
21. **Target derived** - should be related to specific targets that is clearly defined (Neely et al. 1997)
22. **Time-bounded** - value or outcome are shown for a predefined and relevant period (Neely et al. 1997)(Almström et al. 2017)(ISO/DIS:22400-1 2013)
23. **Trend related** - derived from trends rather than snapshots (Neely et al. 1997)
24. **Understandable** - team members understands the meaning of the KPI, particularly in respect to corporate goals (ISO/DIS:22400-1 2013)(Neely et al. 1997)
25. **Valid** - equivalence between the working definition of the KPI and the standard definition (if one exist) (ISO/DIS:22400-1 2013)
26. **Visual impact** - possible to present the result visually (Neely et al. 1997)

3.2.3 KPIs in early development phases

The theoretical information mentioned above mainly refers to KPIs used during the operational stage of manufacturing - the running production phase - as research regarding KPIs during production development phases are limited. Though, a study performed by Wiktorsson et al. (2018) showed that KPIs during early phases indicates that there exists three major challenges related to KPIs used in a production early development context:

- Challenges of understanding the purpose of the specific KPIs
- Lack of data and information about yet not established manufacturing systems
- Lack of link or flow between KPIs in the different lifecycle phases towards the operational stage

Further, these KPIs can be considered being so-called ”enabling indicators”, which are used to later support ”project definition indicators” and finally running production ”operational KPIs” as seen in figure 3.3. According to the authors, this linkage can play an important role in requirements engineering and to ensure future world class performance.

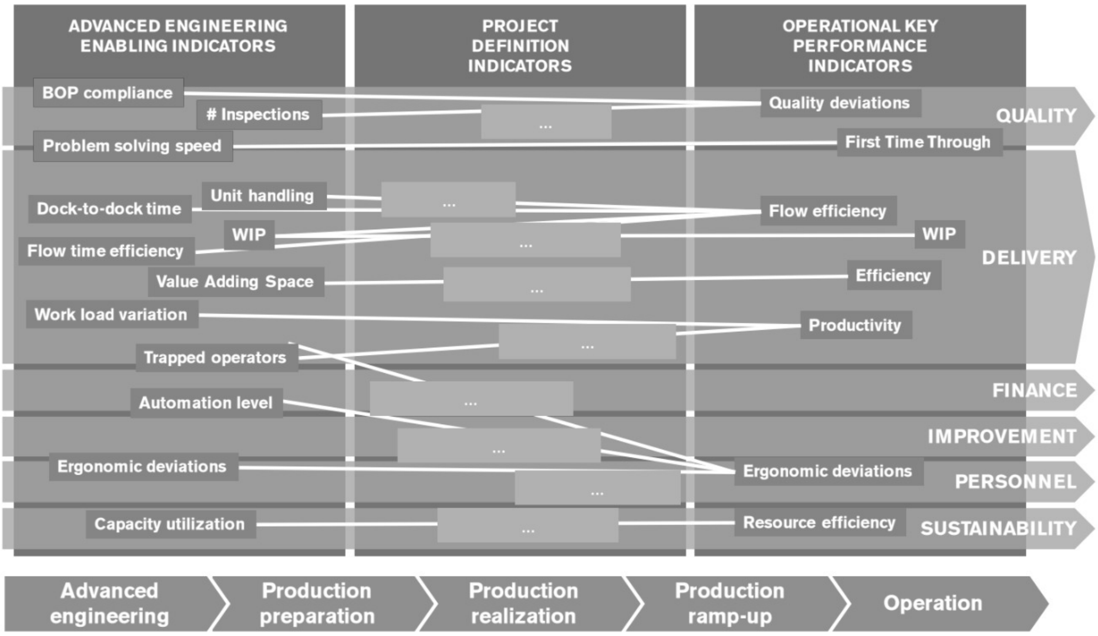


Figure 3.3: Connecting indicators from early development phases with indicators in running production (Almström et al. 2017)

3.3 PMS & KPI success factors and pitfalls

In order to succeed with the implementation of a PMS, it is important to consider the success factor and pitfalls related to KPI usage.

3.3.1 Critical success factors

According to Almström et al. (2017), a successful PMS have several success-factors related to operational development that should be considered:

- Management involvement
- Education and training
- Employee empowerment
- Alignment to long-term strategy

One other important aspect to consider is according to ISO/DIS:22400-1 (2013) that the set of chosen KPIs should be the most effective one for the organization. Considering that it is possible to chose from a large number of potential KPIs, it should be the one that maximizes the organization's chances of achieving an efficient production and higher level business goals that should be selected. Continuously, it is important that manufacturers understands the purpose and usefulness of available KPIs, in order to make the right choices. One way of choosing the right set of KPIs is by looking at its KPI Effectiveness (KPI-E), which is defined by the following formula:

$$E = \frac{1}{N} \sum_{i=1}^{N} w_i E_i$$

where E is the total KPI Effectiveness, N the number of measurements that the KPI consists of, E_i is is the KPI Effectiveness of the i^{th} metric of the KPI (a value between 0 and 1), and w_i is the relative importance of the i^{th} metric (also a value between 0 and 1).

3.3.2 Common Pitfalls

According to Almström et al. (2017), some of the most common PMS and KPI related pitfalls related to PMS and KPI usage is that the organization has:

- Too many KPIs - creates confusion and unclear priorities
- Unclear/complicated KPI definitions - creates lack of accuracy
- KPIs that are not possible to influence on operational level - creates frustration and loss of acceptance
- Sub-optimization - optimizing on one KPI might give negative consequences on the overall value-chain
- Targets exclusively based on historical data - targets should be based both on historical data as well as operational improvement initiatives

These pitfalls should be avoided in order to increase the PMS' usability and ability to affect (Almström et al. 2017).

3.4 Operations Management and Strategy

According to (Slack & Lewis 2010) Operations Management is very tightly connected to Operations Strategy but there are some differences such as Operation Management focus more on the short to medium time-scale, that it is more tangible and that it is largely concerned with managing resources between and within smaller operations. Operation Strategy on the other hand focus more on long term-issues, uses a higher level of abstraction and is more concerned with organisational decisions that affects on a larger scale. This section connects to both Operations Management and Operation Strategy and principles that can be linked to both, as well as their connection to the concept "Operations Excellence".

3.4.1 Operations Excellence and Improvement

Operational Excellence, or in a manufacturing context "World Class Manufacturing", is a wide concept closely related to operational improvement and adaptation of best practices (Kutnick & Allen 2002), including a systematic management of health, environmental and safety in an integrated manner (Nolan & Anderson 2015)

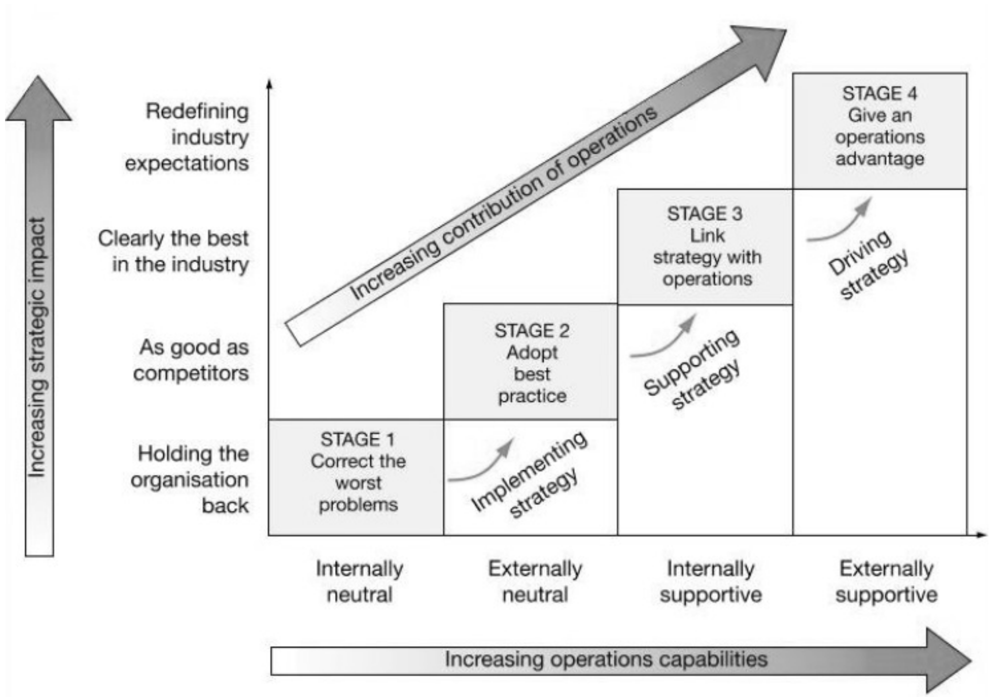


Figure 3.4: Operational Excellence according to the four-stage model (Slack & Lewis 2010)

in order to achieve superior business outcomes. Further, according to Maskell (1991) there are six important areas for world class manufacturing; quality, cost, delivery, lead time, flexibility and employee relationships. In order to achieve this a well-structured improvement methodology should be used. The four-stage-model, seen in figure 3.4, is a model developed by Professors Hayes and Wheelwright of Harvard

University. It emphasizes that the way towards an ”excellence” position relies on four different stages;

In stage 1 the organization’s organization is inward-looking, and the best intervention is to correct the worse problems. In stage 2 the organization aims to become as good as competitors, thus the best arrangement is to adopt best practises. In stage 3 the target is to become best in the industry, something which indicates that strategy should be linked with operations and thus clearly connect them with competitive and strategic objectives. In step 4 the aim is to redefine future industry expectations in order to assure future competitive success. The means that are needed to be taken in this step is to develop the organization’s resources such that they are suitable for long-term strategy (Wheelwright & Hayes 1985).

3.4.2 Manufacturing Strategy

In 1969, an article was published which was about to revolutionize the view of manufacturing and its relation to strategy: "Manufacturing - Missing link in corporate strategy" (Skinner 1969). The article treats the issue of that production units often is managed without respect to overall corporate strategy, separated from the

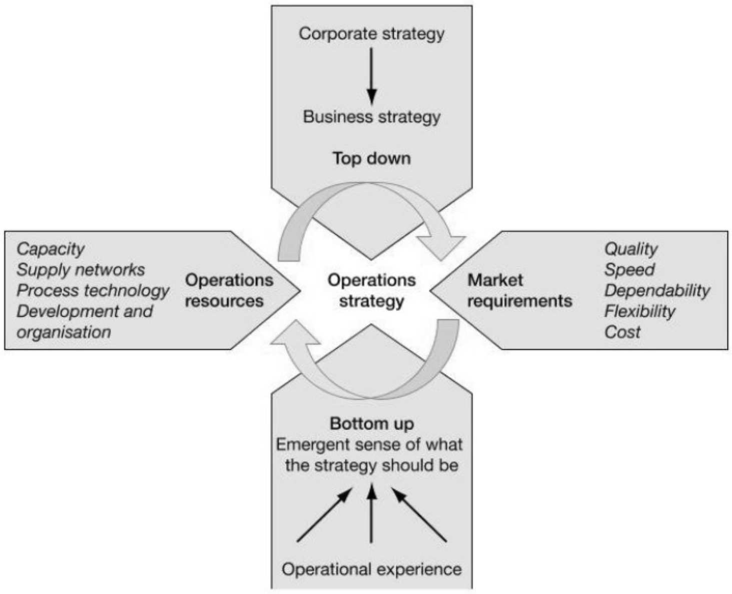


Figure 3.5: Perspectives of operations strategy (Slack & Lewis 2010)

other business units of the company, which is a contradicting act when it comes to traditional strategic management approaches. Since then, it has occurred obvious that manufacturing needs to be connected to corporate strategy, and should not be handled in isolation.

The key concept of manufacturing strategy, or in a wider context *operations strategy*, is the idea of connecting operations with core corporate strategies, looking at the situation from four perspectives - top-down, bottom-up, operations resources and market requirements - to form a comprehensive strategic approach as seen in figure 3.5.

3.4.3 The Operations Strategy Matrix

Manufacturing strategy is the matter of matching performance objectives (from ”operations resources” above) with required performance (”market requirements”) throughout a process that uses both a top-down and bottom-up approach. Translating this into the context of manufacturing strategy, the KPIs can be seen as derived from performance objectives matched with decision categories, as seen in figure 3.6 where the so-called ’Operations Strategy Matrix’ is represented, derived from Total Quality Management (TQM) principles (Slack & Lewis 2010, 32).

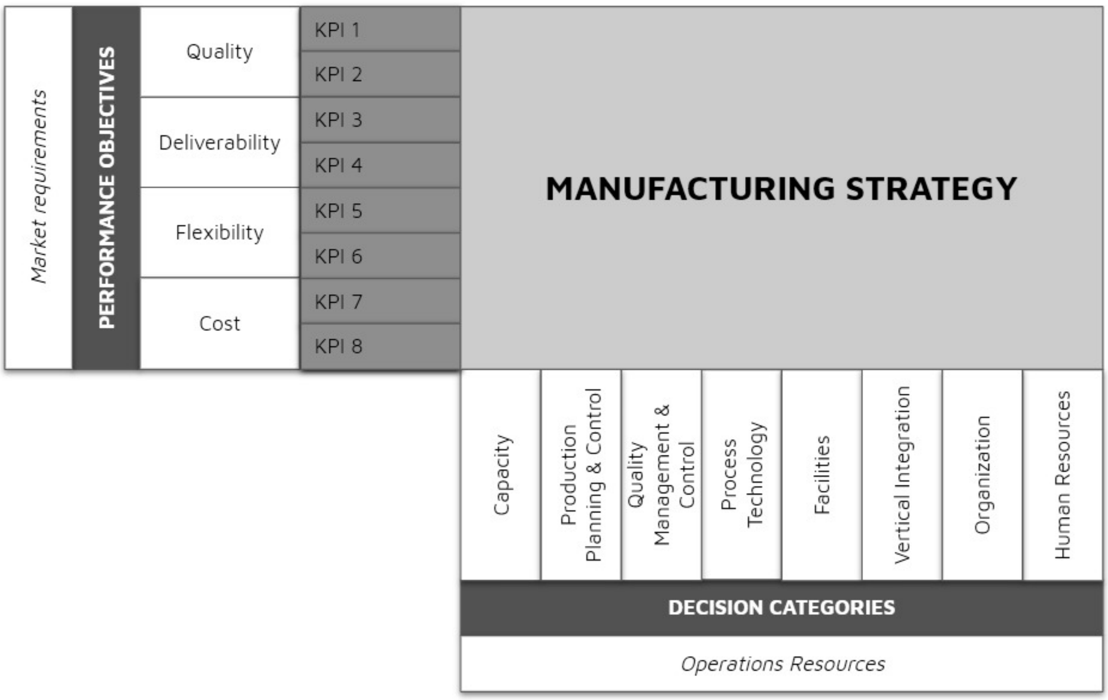


Figure 3.6: The operations strategy matrix (Slack & Lewis 2010)

3.4.4 The Balanced Scorecard

The Balanced Scorecard is a framework developed by Robert S. Kaplan and David Norton in the 1990th, which is widely used for deriving suitable performance measurements from given goals (Landström 2018). In the original framework are the performance measures linked through four perspectives: (1) financial perspectives, (2) internal business perspectives, (3) innovation and learning perspectives and (4) customer perspective (Kaplan & Norton 1992).

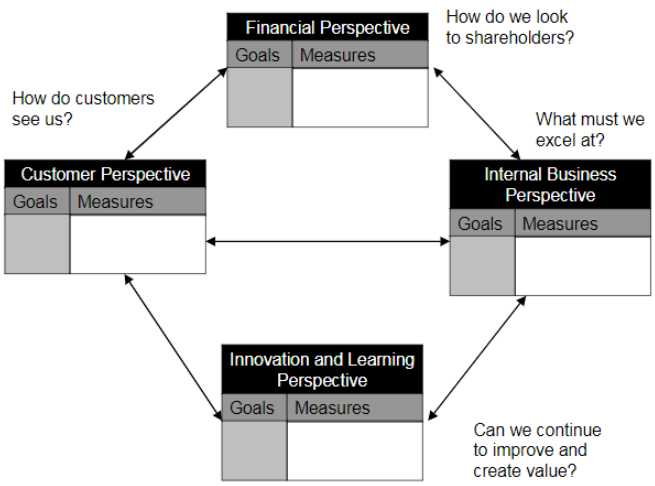


Figure 3.7: The Balanced Scorecard (Kaplan & Norton 1992)

The authors stretches that ”what you measure is what you get”, indicating that all these perspectives must be evaluated, through stating goals and corresponding targets to each perspective, as seen in figure 3.7. Thus, the purpose of the balanced scorecard is to translate the company’s goals into working measures.

3.4.5 Lean Production

Lean production (Lean) , also known as the ”Toyota Production System” or ”TPS”, is one of the most influential management systems in the world, and has triggered a transformation of virtually all industries in the world towards lean thinking and Toyota’s manufacturing system principles (Liker 2004). Still today, Toyota remains on top on plant quality awards, in terms of producing models with fewest defects or malfunctions[1] (Power 2018). The direct result of this success is Toyota’s operational excellence (Liker 2004).

Lean, or TPS, can be describes by 14 principles sorted into four main areas (Problem-solving, People and Partners, Process and Philosophy), as seen in figure 3.8.

A lot of the Lean principles circles around the creation of ”flow”, as well as elimination of ”waste”. To further define this, lean production can be characterized through a five-step process (Liker 2004):

1. The definition of customer value
2. The definition of the value stream
3. The creation of flow (make the product flow through value-adding processes without interruption, a ’one-piece flow’)
4. The creation of pull (from the customer back, replenishing only what the next operation takes away at short intervals)
5. The thrive for excellence (create a culture in which everybody is striving continuously to improve)

[1]Including the assemble of Toyota’s premium subsidiary car brand Lexus

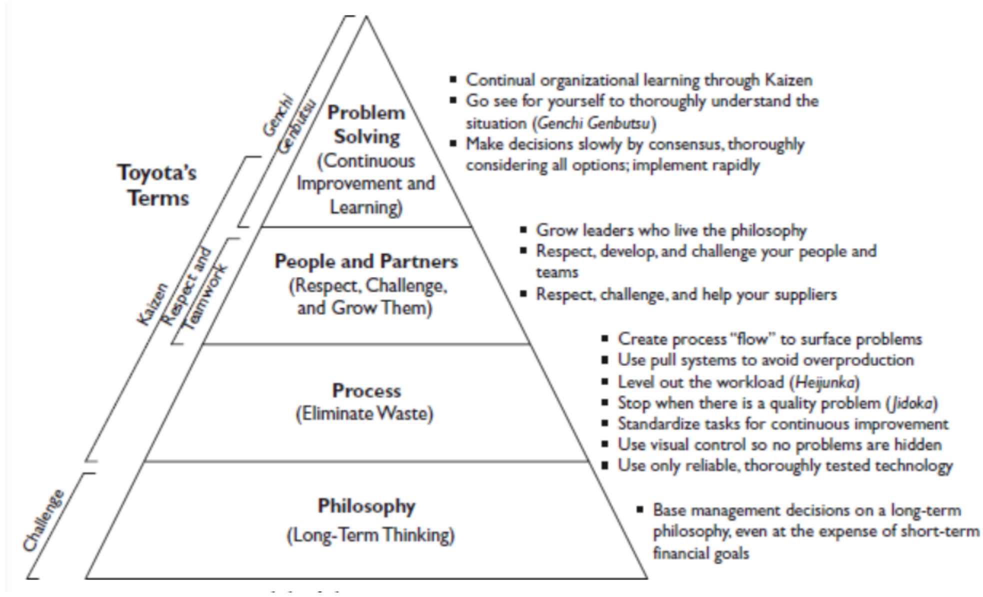


Figure 3.8: The Toyota Way through 4P (Liker 2004)

3.4.6 Gap management and the ideal state

When it comes to operational improvement, one of the key objectives of TPS is to ”understand the current condition in relation to the ideal process” (Stewart 2012). This includes the task of an organization to both being able to describe the organization's current state, as well as being able to define what an ideal state indicates.

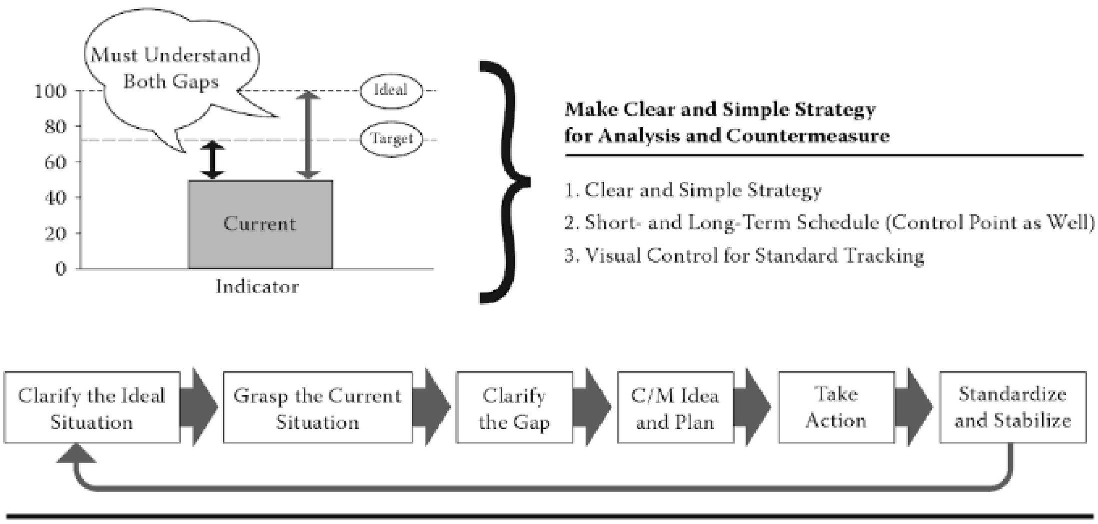


Figure 3.9: The gap management process (Stewart 2012)

By this, it is possible to identify the gap that exists between current state and the best way of manufacturing. There exists six steps in ”lean gap management”, where the first step circles around clarifying the ideal state, as seen in figure 3.9.

Because an ideal state often is difficult to reach, a target close to the ideal state should be defined. This step is done before the current state is identified (step 2), and the gap can be clarified (step 3). When the gap is defined it is possible to perform step 4 and define the plan needed in order to close it, by developing countermeasurements. Step 5 implies the practical action taking on the plan, and step 6 (the last step) indicates that once the targets have been reached, the process has be be stabilized and standardized in order to sustain the achieved results. (Stewart 2012, 85-86).

3.4.7 Trade-offs

According to Anderson et al. (1989) a trade-off means that one is giving one operation objective preferential treatment over another. Slack & Lewis (2010) explains the concept of trade-off as having to sacrifice one thing to gain another. Depending on the wanted variety for products or services companies, or different operations, can choose to place themselves different, presumable due to differences in their market strategies, in relation to cost efficiency (Slack & Lewis 2010). The perspective of trade-offs between product or service variety in relation to cost efficiency can be seen in figure 3.10. The process of making trade-offs decisions is often painful but the organization cannot recognize or evaluate the existing corresponding alternatives without knowing what must be reduced in priority or compromised to achieve an objective Anderson et al. (1989).

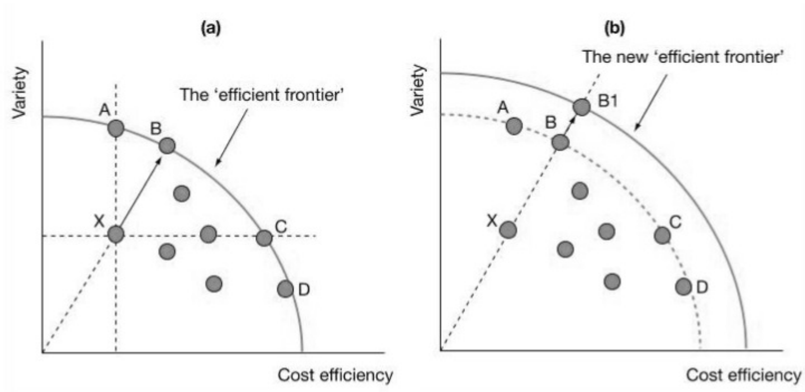


Figure 3.10: Perspectives of trade-offs and the efficient frontier (Slack & Lewis 2010)

3.5 Future industry: Industry 4.0

According to Zeller et al. (2018) more and more companies are trying to implement computerization, the first step towards in Industry 4.0. The term "Industrie 4.0" (or Industry 4.0 in English) has become a collected name for new technologies within manufacturing and concepts such as digitalisation and interconnectedness (Schuh et al. 2017). Industry 4.0 has it roots in Germany and refers to the fourth industrial revolution (after Mechanisation, Electricity, and Information Technology) that will come thanks to the concepts Internet of service and Internet of things connected with manufacturing (Gilchrist 2016). Industry 4.0 will transform industry, foremost in areas of agility and flexibility e.g. monitor manufacturing systems in real time (Schuh et al. 2017).

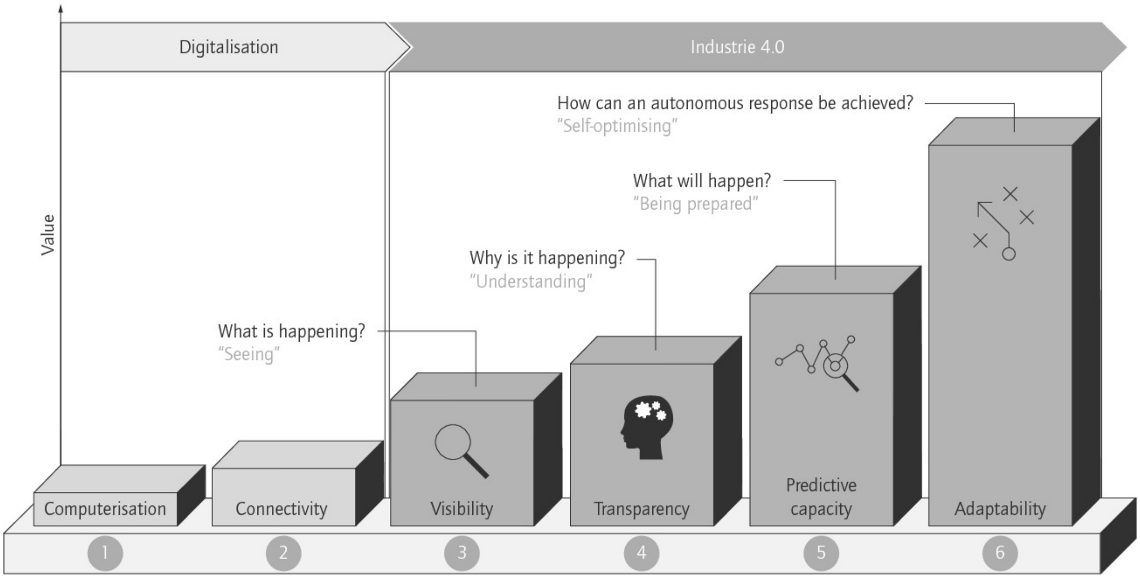


Figure 3.11: The stages of development in Industry 4.0 (Schuh et al. 2017)

According to the Industrie 4.0 Maturity Index (Schuh et al. 2017) there are six stages to fully achieving Industry 4.0. These six stages are the following: 1. Computerisation, 2. Connectivity, 3. Visibility, 4. Transparency, 5. Predictive capacity and 6. Adaptability. The six stages in the Industrie 4.0 Maturity Index can be seen in figure 3.11.

4
Case Context

According to Bazire & Brézillon (2005) it is important to understand the situation's context, the set of constraints which influence the behavior of a system in a given task, in order to make a correct analysis provide proper recommendations. In the same way it is important to understand BIW's context in which they operate within before present and future state can be evaluated. The information below is based upon studies of the work place as well as internal documents from BIW.

4.1 Organisational structure

Body in White (BIW), as seen in figure 4.1, is a business unit which hierarchically lies under the main business area *Manufacturing & Logistics*, consisting of several business units where *Manufacturing Engineering* is the one which embodies the function investigated for this thesis: Body in White (BIW). In figure 4.1, grey boxes implies departments where interviews have been conducted and bold text are the departments connected to BIW.

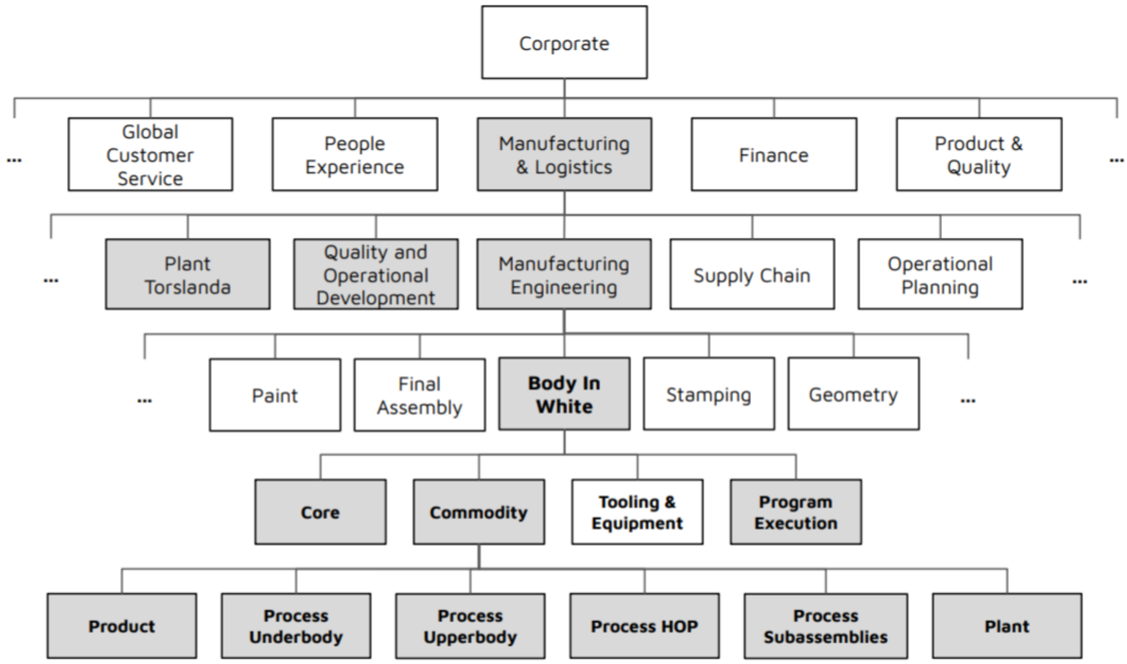


Figure 4.1: Organizational scheme of Volvo Cars and BIW

Recently, Volvo Cars' has gone through a lot of organizational changes, including reorganization of the business functions and responsibility areas, new strategies and agile working methods. This has affected both Manufacturing & Logistics (M&L) as well as Product & Quality (P&Q, the Research and Development unit), which both have gone through extensively changes but in different ways. These changes has taken place during the same time as this study has performed, and which continuously has affected the research results. Below follows a brief introduction of the functions dealt with (in any form) for this thesis.

4.1.1 Manufacturing & Logistics (M&L)

M&L is a global business area that has the responsibility of building and delivering cars, with the mission to ”Build production excellence on people’s competence and engagement”. It is the business unit that incorporates Manufacturing Engineering, which BIW is a part of, besides other functions such as the Plants, Supply Chain, Operational Planning etc.

4.1.2 Manufacturing Engineering (ME)

ME is a global function with responsibility to introduce (launch) new car programs and processes in Volvo Cars plants or Joint ventures/partners, with the mission to ”develop global lean production processes to create the best manufacturing envirionments”.

ME’s main ’customers’ are the manufacturing plants which is approached through different product or process projects, to whom they supply installations of equipment, industrial strategy plans, methods and know-how. Their vision is to create world class, lean, highly efficient and flexible production systems all over the world. At the same time, they work closely with Volvo Car’s Product Development department (Product & Quality). Their relation to these two departments can be seen in figure 4.2.

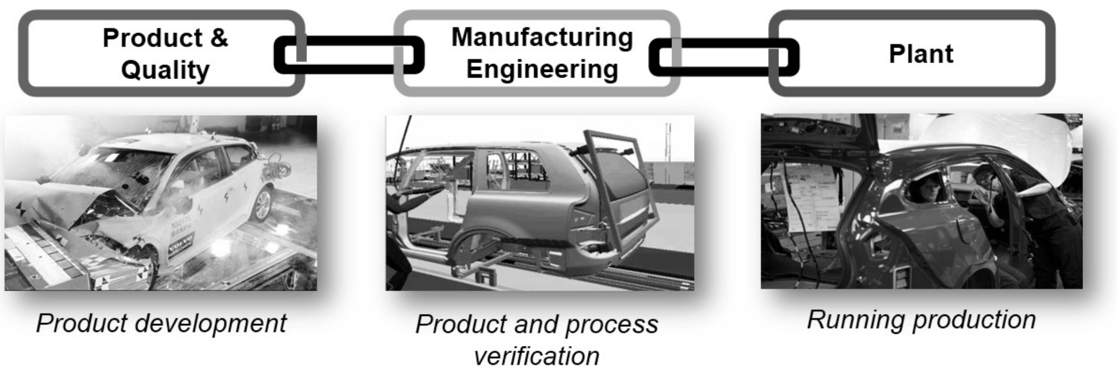


Figure 4.2: ME’s link between P&Q and Plant (internal document, Volvo Cars)

Product & Quality (P&Q) is responsible for creating prerequisites and drive the development of products according to Volvo’s Brand Strategy and Product Cycle Plan, including transforming ideas to innovations in order to meet the high standards of future vehicles, whereas The Plants is responsible for the work performed during running production phase, for each separate production site.

4.1.3 Body in White (BIW)

The main task of BIW is to implement vehicle programs, change orders and engineering changes in respective global production site. They develop, implement, introduce and maintain quality-assured, effective and standardized production systems according to set targets. Further, they ensure a process-driven product development with focus on effective and quality assured production, and securing product fulfillment of manufacturing prerequisites. This through either so-called ”greenfield” projects (completely new plant) or ”brownfield” projects (modifications of already existing plants). BIW consists of four main sub-units, as seen in figure 4.1; Core, Commodity, Tooling & Equipment and Program Execution.

Core: is the strategic function of BIW. They are involved in the earliest development phases and mainly responsible for high level requirements for respectively plant, high level plant layouts, new technologies, rough cost estimations and similar tasks.

Commodity: is involved during the preparation and implementation phases, and is divided into several parts - Underbody, Upperbody, Hang-on Parts, Subassemblies, Plant EMEA/US and Plant APAC. They ensure the inputs to Analysis and Verification needs, drive and follow-up quality, man hours, cost efficiency, environment, flexibility, etc.

Tooling & Equipment: is responsible for the implementation of process related equipment for our plants in all car project phases, as well as in running production. Note that this department has not been included in the performed interviews, as they are partly delimited from the rest of BIW, working more closely to running production.

Program Execution: is responsible for performing ”perfect industrialization and execution”, within the frames of time balancing, techniques and costs inside program frames.

4.2 Development Processes

All development work in Volvo Cars is performed in relation to Volvo Cars' internal Product Development System (VPDS). VPDS describes the different development phases of a car, including Prototypes building, Feasibility study, Design, Mechanical system development et.al., and how these are connected to business milestones.

BIW's development phases starts at the milestone program strategy (PSI) and stretches until running production start (J1) plus 90 days. As seen in figure 4.3, Core is involved in the early phases (until plant concept is approved) and ramps down at the same time as Tooling & Equipment ramps up. Commodity is present from right before plant concept is approved until J1 plus 90 days, during the same time as Program Execution is active.

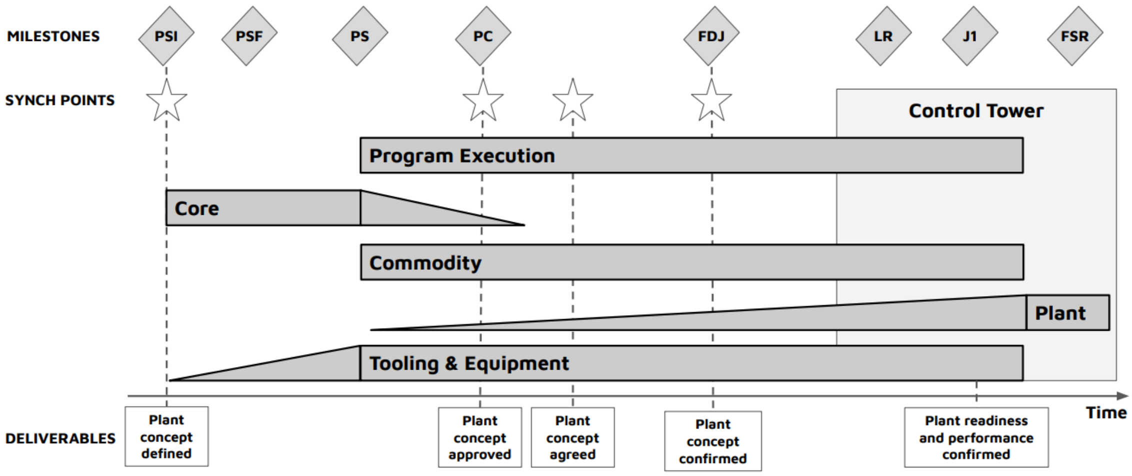


Figure 4.3: BIW - Overall Logical Plan

Connecting this to the figure described in 3.2.3 which shows the connection of ”enabling indicators”, it can be noticed that BIW works in the ”Advanced engineering” (AE) and ”Production preparation” (PP) phases, also defined as ”early production development phases”.

4.3 M&L strategies and objectives

BIW is working in the context of M&L’s strategies and agendas, and it is continuously important to understand the specific situation in order to develop suitable recommendations. Below follows some important themes that affects BIW in their daily work:

Manufacturing & Logistics have five targets which is aimed to be achieved by 2020, related to the following areas:

(1) Costs
(2) Health & Safety
(3) Quality
(4) Lead-time
(5) Tied-up capital

It is partly up to separate units under M&L (Supply Chain, Manufacturing Engineering, Operational Planning etc.) to ensure that these targets are fulfilled. This continuously affects BIW and how they should manage their operational improvements. Recently, M&L have also started to use the concept of ”Ideal State”, as part of the lean transformation. As seen in section 3.4.5 this refers to a gap management approach where the ideal state of production operations needs to be envisioned, in order to see the steps required to obtain operational improvement. The developed PMs is closely connected to the ideal state work, as the strategic work surrounding these topics have been done by the same people and in the same forums.

5

Present state: Findings

In the following chapter the empirical findings related to present state are presented. The information is mainly based on findings from the interviews, but also from empirical data from observations and written data.

5.1 Performance Measurement structure

BIW has today one set of PMs that is currently used within the organization, which is comprised of 7 KPIs and 11 Measurables, and which have been developed by the Core team together with members from Top Management. The full set of current PMs can be seen in figure 5.1

Table 5.1: Current PMs at BIW: Including depending variables

	PERFORMANCE MEASUREMENTS	UNIT	DEPENDING VARIABLES
KPIs	Manufacturing cost per car	SEK	Investment, Field-type, Direct Manning at 100%, Project Location, Sqm, WIP cost, JPH
	Investment	SEK	Investment
	Square meter	#	Sqm
	Manpower flexibility	%	Direct Manning at 100%, Direct Manning at 50%
	Operator utilization	%	VA, NVA, NNVA, Cycle time
	Machine utilization	%	Machine time, Cycle time
	Line utilization	%	VA stations, NVA stations
MEASURABLES	Customer demand	#	Yearly volume, Net available time
	Line technical availability (OPR)	%	Production time, Stop time, Net available time
	Automation ratio/level	%	Automated stations, Manual stations
	Direct manning	#	Direct Manning
	Designed cycle time	HH:MM:SS	Cycle time
	Ergonomic	#	Ergonomic red stations
	Amount of F-packs	#	Robots
	Throughput time (lead time)	HH:MM:SS	Lead time
	Number of build steps	#	Building steps
	Number of articles per car program	#	Articles
	Joining equivalent	#	Joining equivalents

According to the interviewees, a *Measurable* is an extra measures that motivates and explains the KPIs and their corresponding values. One interviewee stated it like this:

> *"They should explain total manufacturing costs, they should be connected to the KPIs and give a bigger dimension"*
>
> — Senior Director BIW

An initial set of Performance Measures was developed two years ago, and has since then been revised through an iterative process, internally through weekly meetings with members from BIW, and externally through regular meetings with the steering group. It is also Core that sets the target values of each PM, where some of the PMs have project or product dependent targets, whereas some others have "generally" set targets, derived from internal checklists.

5.2 Performance Measurement's role and purpose

The PMs are internally referred to as one of BIW's "steering documents", indicating that they are used for steering the BIW organization towards a better state. Considering that BIW is target-driven rather than "strategy-creating", it can be highlighted that the set of PMs should help them towards already set targets and implementing higher-level strategies, rather than creating new ones.

Traditionally are KPIs used in operational process monitoring, and are as described in 3.2 used for either improving, reporting or controlling purposes. Though, from the interviews did it became clear that the KPI's purpose during early production development phases differs a bit from this "traditional" structure - more aspects of the term "Purpose" have to be covered. Further, it was revealed that the purpose of the KPIs differed for different stakeholder groups. Five different stakeholder groups was identified: Top Management (M&L/ME), Top Management (BIW), Managers (BIW), Engineers (BIW) and Program Managers (BIW).

For example, one of the interviewees (in the "Top Management" segment) stated that:

> *"The KPIs are there to drive. Drive the right behavior and thinking"*
>
> — Vice President ME

One other interviewee, also in the top management segment, referred to the KPIs to more of a tool for evaluation and improvement:

> *"We use them for evaluating and improve, to get better, to see if we have good solutions"*
>
> — Senior Director ME

At the same time, an other interviewee, in the Managers segment, stated the following:

"The way we do now is mainly reporting"

— Manager BIW

With basis from the 'Problem & Needs Analysis" which can be find in Appendix B, a stakeholder analysis could be performed according to 5.1, where the identified stakeholder groups was mapped together with related purposes.

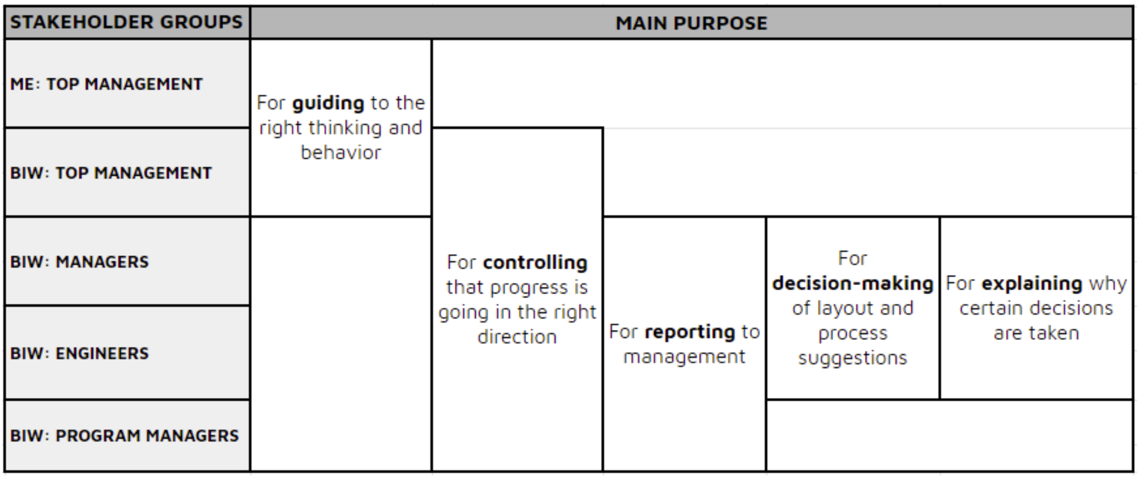


Figure 5.1: Purpose of the KPIs in relation to the main stakeholders

The figure visualizes how the stakeholder groups' perception of the KPIs' purposes differ and overlap between each other. A more detailed list of the stakeholders purposes of the measures can be seen below:

Purpose 1: "For guiding purposes"
- To drive the right kind of thinking among employees
- To create an alignment of thinking within the organization

Purpose 2: "For controlling purposes"
- To making sure that current objectives are reached
- To follow up the progress of ongoing projects
- To follow up progress between current and previous projects
- To follow up the performance of implemented solutions (between ME and the Plant)

Purpose 3: "For reporting purposes"
- To report the results to Top Management

Purpose 4: "For decision-making purposes"
- To help compare layout suggestions against each other
- To help compare layout suggestions against current layout
- To help compare new layouts against current layouts
- To help compare new layouts against ideal state layouts

Purpose 5: "For explaining purposes"
- To motivate why certain decisions are taken

Continuously, the "lower-level" oriented stakeholder groups, Engineers and Managers, want to use the KPIs as sharp tools in the decision-making process, using the results in order to explain other results (e.g. showing why trade-offs are necessary), and by pure reporting purposes. At the same time, the "higher-level" oriented stakeholders groups, Top Management in particular, wants the KPIs to be used as a kind of "guiding" tool, giving instructions of how to think and focus upon. The purpose which affects most of the groups is controlling, in regard to follow up progress towards current targets.

5.3 A macro perspective of the PMS management

The full management of the PMs, BIW's Performance Measurement System, can be seen in figure 5.2. This is illustrated by the KPI lifecycle developed by Almström et.al (2017), described in chapter 3.1, where the BIW-team responsible for each activity are placed within each box.

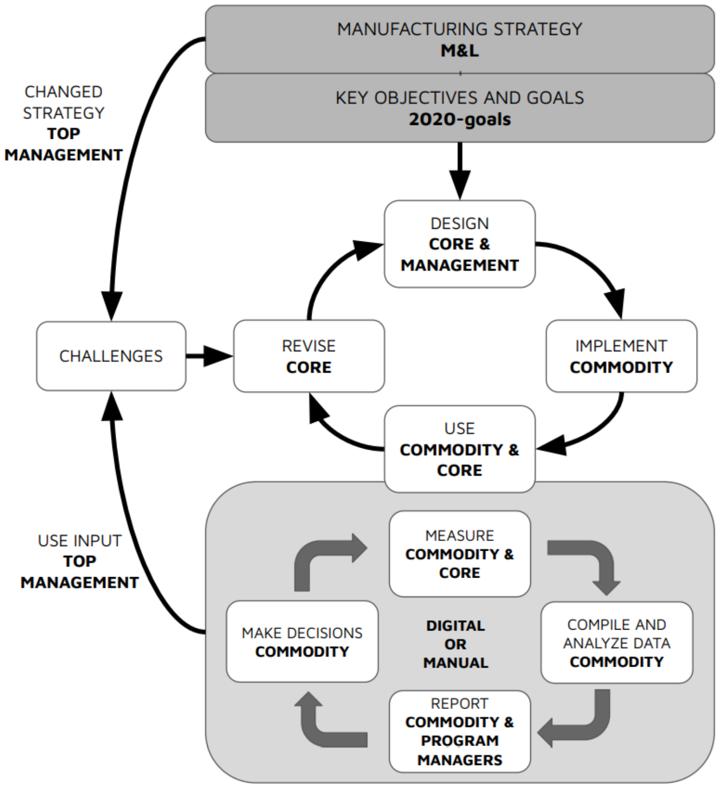


Figure 5.2: The current KPI lifecycle at BIW (based on the KPI lifecycle by Almström et al. (2017))

It is, as previous mentioned, the Core team together with members from Management that is responsible for the design phase, whereas Commodity is is responsible for the Implementation phases as well as main responsible for the usage phase (although the Core team also makes certain measurements during this period).

Though, in the end it is the Commodity team that uses the PM results in order to analyze the data, report the numbers and making decisions, and Top Management which uses the data for making external evaluations and provide input for the revising phase, which Core is mainly responsible for.

5.4 The Performance Measurement Lifecycle

The PM lifecycle description is based upon the four main parts of the KPI lifecycle; Design, Implement, Use and Revise.

5.4.1 Design

As mentioned is Core the team that is mainly responsible for the design of the PMs. The majority of the interviewees stated that they find the current PMs good, especially when it comes to the big impact they have had on the organization's changed focus on process design and what to focus upon. As one interviewee stated it:

> *"The KPIs we have today are very good as they steer us in a good direction"*
>
> — Engineer BIW

At the same time, one other interviewee claimed that:

> *"Honestly, I have difficulty understanding what the purpose of the KPIs are, and how to use them"*
>
> — Engineer BIW

Continuously, current set of PMs both possess strengths and weaknesses, in relation to how stakeholders looks upon them. Further, when it comes to the prioritization of current PMs - of which PM that is most important - the following can be noticed:

- Top management have a major business-orientation towards KPI prioritization
- Top management wants to "get away" from short-running thinking towards more long-term thinking
- Engineers have major process-oriented approach towards KPI prioritization
- Managers have a mix of both aspects

Further, it was from the interviews revealed that there exists two main areas which is believed being important to the organisation but currently "missing" in the current structure, as well as lack of certain Measurables:

- Lack of *Human-centric KPIs* - current KPIs misses out on how good/bad the line are for the operator
- Lack of *Quality KPIs* - current KPIs misses out on quality aspects (process robustness and geometrical variation)

- Lack of Measurables that covers up for ”hidden facts” - factors that makes the KPI value looks extra good/bad, the actual content of a process

Though, it should be noticed that this is areas highlighted from a employee point of view, and not necessary areas which needs to be covered by PMs.

5.4.2 Implementation

Currently it is the Commodity team that is responsible for implementing the measurements (the KPIs and Measurables) at BIW. According to the interviews there exists no standard work procedure for how to collect the data and where to find it. Interviewees, both managers and engineers, also states that there has been uncertainties in the implementation process, both regarding how employees are understanding the process but also that there is a lack of motivation because of inadequate management. Furthermore, it is important to emphasize that the lack of understanding also affects the separate KPIs, one example of this is the KPI ”Square meter” and the Measurable ”Amount of Robots”:

> *“I don’t understand Square meter at all, it leads to worse processes”*
>
> — Engineer BIW

> *“Amount of Robots is a very dangerous number. Only management cares about it”*
>
> — Program Manager BIW

One problem that was highlighted from a system manufacturing engineering (SME) point of view was the lack of time given for education about the PMs. As one interviewee mentioned:

> *“We need to sit isolated and try and test, not only for a few hours. We would reach much further then”*
>
> — Engineer BIW

It was emphasized that PM information exist, but not enough time have been given for actual education and making sure that the employees using the PMs understands how and why to use the information.

5.4.3 Usage

According to Almström et al. (2017) the using phase includes to measure data, compile and analyze data, report the data and finally make decisions based on the data. Currently it is mainly the Commodity team, but also to some extent the Core team, that is "using" the measurements (depending on which phase they are within).

Data collection: compiling and analyzing data

Mentioned in the previous section, there doesn't exist any standard way of how to measure or compile and analyze the data. The system manufacturing engineers (SMEs) are the ones responsible for collecting and calculating the PM values, and it seems like, according to the interviews, that the data is collected in rather different ways - some by manual calculations and some by extractions directly from computer software's. Further, it was revealed that the data collection involves many different employees, something which makes it time consuming to gather the data. Due to this, some of the interviewees also questioned the trustworthiness of the data. One of the interviewee stated the following about this:

> *"I need to speak to 10 different people to get the data, difficult to know if what they are saying is correct"*
>
> — Engineer BIW

The time-consumption is not only an effect from the data collection but also from the actual calculation of the KPIs; how to, in the specific situation, interpret the KPI formula. One other aspect highlighted by a larger number of stakeholders, was the lack of KPI centralization. One interviewee stated the following:

> *"We often get a target: next project should be 10% better but we have no place where previous results are stored. Does the lines get better or not? We don't know"*
>
> — Manager BIW

Data is stored at at least three different places to cover the different needs - one data sheet internally at ones computer, one at Sharepoint and one at the Project dishes.

Reporting and making decisions:

When the data is collected, the results is sent to the Program Manager (and sometimes Managers) by email, and sometimes reported directly into the reporting system 'PSR'. What is happening to results after they are reported remains unanswered, as that was something the interviewees couldn't answer for:

> *"Where does the data end up after it is used? PSR? Is that good or bad? It is not very clearly. How does the feedback happen after the data is processed? We don't know"*
>
> — Engineer BIW

Based on the findings, it can be assumed that the process of reporting is not yet fully defined, alternatively poorly communicated out by Top Management. The results is reported before each gate, and it could be concluded that at least some of the results are evaluated by the steering group, which uses the values to judge different layout solutions. The process of reporting into PSR also lacks essential properties to serve as a good reporting system. PSR is built on a system with indicating colours (where e.g. green indicates ”Good” and red ”Bad”), though given the situation with uncertainty in data and difficulty to compare the results, the method isn't suitable. This is also related to that targets are lacking in the system, and that no possibilities are given to comment the results (explaining why the result looks like it does).

> *“The bad thing about PSR is that if it shows red, we still continue forward. I have got from my PM that I need to mark it as yellow [no matter the results]”*
>
> — Engineer BIW

When it comes to the decision-making part of the usage, there have been identified that there have existed a tradition of making ”decisions based on feelings” - or at least that this have been the perception among the employees. One of the interviewees stated the following:

> *“We need to make decisions based on facts, not based on peoples feelings of what they think is the problem”*
>
> — Manager BIW

5.4.4 Revision

Currently the revision of the PMs are done by Core together with input from Top Management. The KPIs and Measurables have been revised every 6 months and presented on special strategic events. From the interviews was it mainly revealed that the performed revising of current PMs have been successful, and that they today are better and easier to understand compared to when the first set was introduced. Moreover, the revising to current set of PMs have helped them to change mindset from mainly short-term targets (e.g investment) towards more long-term goals (e.g. manufacturing cost per car), although some interviewees still stated that today's objectives and focus' is still focusing upon short-run targets rather than long-term objectives.

5.5 Strategic Alignment of PMs

Currently, the main work related to ”alignment” in a PMS content, is alignment conducted within the BIW organisation. Although Top Management have, partly, been a part of the design phase and the current performance Measurements are being revised every 6 months, there does not exist any specific work procedure or planned activities related to this field.

Several interviewees stated that they miss a clear connection between the PMs and current strategic targets, nor a clear idea of how current targets and higher-level strategies affects BIW in their daily work. The PMs have been designed and revised in the absence of a clear connection to strategy and/or separate departments.

5.6 Future industry

Part of the interviews was regarding new technologies and Industry 4.0 (I40), see Appendix A. This in order to cover external factors that might affect BIW and their management of current and/or future Performance Measurements.

According to the interviewees there exists smaller projects that relates to new technologies such as simulations through Virtual Reality et.al., but there are no actual plans or strategies currently in place (at BIW) that aims of implementing new technology or work procedure in order to reach I40, both in relation to BIW's internal processes nor in the production development of future solutions. The following statement was made from interviewees of the Top Management segment:

> *"There are things going on, but it is not as much going on as we might have hoped. We have to many systems that are not connected to each other"*
>
> — Top Management BIW

Many of the interviewees also stated that they think that BIW can benefit from new smart technical solutions such as Artificial Intelligence, Big Data, Internet of Things, Connected Systems and Digitalisation.

6
Present state: Analysis

In the following chapter the empirical findings from present state are evaluated and discussed in relation to its strengths, problems and needs. The main source of the analysis and related conclusions are from the "Problem & Needs"-analysis that can be found in Appendix B.

6.1 Structure Analysis

From section 5.1 it could be noticed that the division between a "KPI" and a "Measurable" is somehow obscure, with some Measurables that is incorporated in the KPIs (such as *Direct Manning*), and others that is completely separated from the KPIs (such as *Ergonomics*). This relation, or lack of relation, was also highlighted during the interviews. Further, it was announced that it was sometimes difficult to see their connection to current KPIs in general, and their purpose's in particular.

> *"Right now is the Measurables almost like KPIs, it is difficult to read and understand from current list. They are quite useless right now"*
>
> — Engineer BIW

Further, it is important to emphasize that current KPIs is all of *leading* type, besides Manufacturing cost per car which is more of a *lagging* type of KPI. Thus, the KPIs concerning utilization, flexibility, investment and square meter is more of 'process-oriented' PMs, which supports the end-result, whereas Manufacturing cost per car is 'result-oriented'. A deeper KPI analysis, with respect to the KPI criteria from chapter 3.2.2, was performed and can be seen in table 6.1. It can from this be noticed that Manufacturing cost per car, Investment, and Square meter are three KPIs which currently holds most "critical" weaknesses, with respect to that they all are absolute numbers and no ratios, which through the interviews was related to difficulties. For instance, having only numbers and no ratios leads to difficulties when it comes to target-setting, which also was revealed through the interviews as current problems:

> *"We are struggling to compare the KPIs to something"*
>
> — Engineer BIW

> *"We don't measure apple with apple today"*
>
> — Manager BIW

Actually, to matter of comparing ”apple-to-apple” is very important when it comes to data management. According to McKinsey&Company (2019) is one of the key elements when it comes to succeeding with digital performance management to have ”clear mechanisms to ensure KPIs are apples-to-apple and not manipulated”.

Table 6.1: KPI analysis: the current KPIs at BIW compared to the criteria stated in section 3.2.2

	KPIs						
Areas to be fulfilled	Manufacturing cost/car (SEK)	Investment (SEK)	Square meter (m2)	Manpower flexability (%)	Operator utilization (%)	Machine utilization (%)	Line utilization level (%)
Accessible	Does not include energy consumption, indirect manning and logistics costs	Does not consider changed costs over time, not clear what is type-bounded and pricelist ony valid in Europe					
Achievable	Includes elements (investment) that is not always possible to influence	**Not always possible to affect**					
Aligned							
Balanced	Includes investment and sqm	Included in MFC/car	Included in MFC/car				
Calculable							
Comparable	Lack of data	Lack of data	Lack of data	Lack of data	Lack of data	Lack of data	Lack of data
Consistent							
Documented							
Feedback oriented	Difficult to relate if reached SEK value are good/bad	Difficult to relate if reached SEK value are good/bad	- Difficult to relate if reached m2 value are good/bad				
Improvement related							
Information providing							
Predictive	(Not applicable in production planning context)						
Quality of data	- Lack of data of values in running production	- Lack of data of values in running production	- Lack of data of values in running production	- Lack of data of values in running production	- Lack of data of values in running production	- Lack of data of values in running production	- Lack of data of values in running production
Quantifiable							
Ratios	**- No ratio, a number**	**- No ratio, a number**	**- No ratio, a number**				
Relevant							
Simple	- Complex formula						
Specific							
Strategy derived							
Support			**- Employees don't fully support the KPIs existance**				
Target derived	**- Lacks target value**	**- Lacks target value**	**- Lacks target value**				
Time-bounded	(Not applicable in production planning context)						
Trend related	(Not applicable in production planning context)						
Understandable			**- Employees do not understand the purpose**				
Valid				- Possible risk for suboptimizing			
Visual impact							

Further, the definition of the KPIs and how they are presented today is another highlighted problem:

> *"We would like to have an order where the most important KPI is highest, and what is connected to what"*
>
> — Engineer BIW

Relating this to "common pitfalls", described in section 3.3, it can be noticed that unclear KPI definitions creates lack of accuracy, which might be a consequence of the problems described in section 5.1. Furthermore, for all KPIs could it be noticed that the criteria "Comparable" and "Quality of data" is not fully fulfilled (as seen in table 6.1) due to lack of data of previous solutions and from running production.

6.2 Purpose Analysis

From 5.2 could it be noticed that the purposes in early production development differ a bit from the 'traditional' description of a PM's aim. The following differences can be highlighted:

1. **Guiding/Driving** - a new identified purpose, compared to traditional view
2. **Supporting in decision making** - a modified purpose, compared to traditional view
3. **Explaining** - a new identified purpose, compared to traditional view

Guiding/Driving and Explaining are new purposes, compared to running production KPIs, whereas Supporting in Decision making is modified; KPIs in running production are also used for decision-making, but where the process is mainly based on historical performance in order to make strategic decisions. In production development phases on the other hand, decision-making in mainly based in selection processes, to compare and chose between solutions.

In order to understand how the purposes relates to inputs, outputs, resources and controls, an analysis inspired by the process mapping method IDEF0 was used. IDEF0 gave new dimensions to the different purposes in a standardized way, and resulted in "activity" or "purpose" maps that can be seen in figure 6.1 and figure 6.2 (the bold boxes indicates that it does not existing today).

Considering purpose (1), Guiding, it can be seen that the actual KPIs can be seen as the purpose's output, given that they are the ones that should support the organization's way of working. Given the "inputs" and "controls", it can be seen that what is missing today is some kind of resource related to KPI storage. For purpose (2), Decision-making, the same conclusion could be drawn - in order to make the activity "complete" is some kind of decision-making function missing, related to given pre-conditions and KPIs.

For purpose (3), Controlling, (4) Explaining and (5) Reporting, could similar conclusions be made; in all cases is some kind of IT-tool function missing, related to both some kind of controlling and feedback function, an explaining dashboard and input function (of element values).

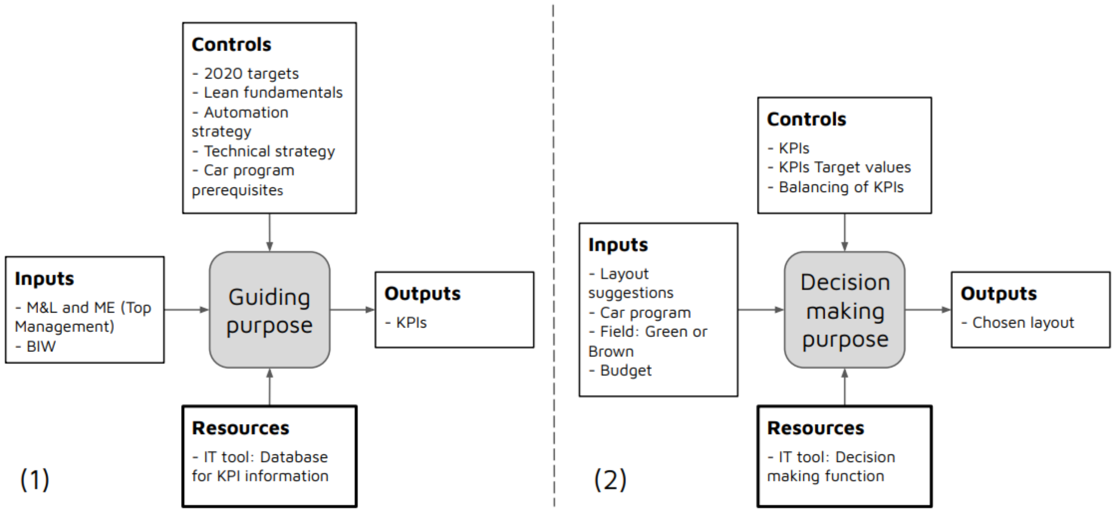


Figure 6.1: IDEF0-inspired analysis of KPI Purpose (1) Guiding and (2) Decision making

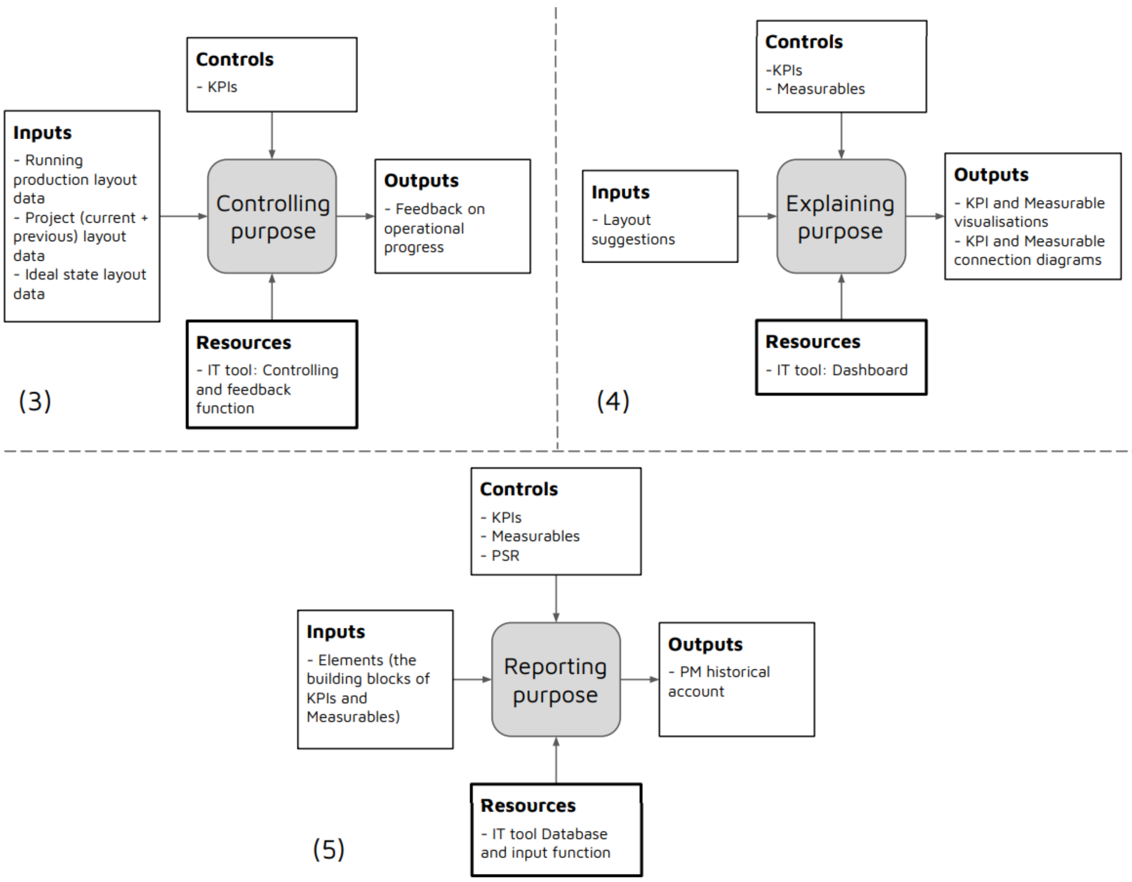


Figure 6.2: IDEF0-inspired analysis of KPI Purpose (3) Controlling, (4) Explaining and (5) Reporting

6.3 Lifecycle Analysis

The findings from 'The Performance Measurement Lifecycle' in 5.4 is analysed below, supported by additional information from the Problems & Needs analysis.

6.3.1 Design

Considering the prioritization of PMs from section 5.4.1, it can be concluded that the KPI "Manufacturing cost per car" is the most important KPI according to the stakeholder group Top Management, as it takes both cost and long-term thinking into consideration, whereas Managers and Engineers tends to focus more upon the utilization and flexibility KPIs.

Some interviewees mentioned that there might exist contradicting aspects between the PMs and certain objectives, where some of the highlighted issues was related between:

- Utilization (KPI) with Quality (BIW Objective)
- Investment (KPI) with Ergonomics (Measurable)
- Line technical availability (Measurable) with Square meter (KPI)
- Manufacturing cost per car (KPI) with Strategies (BIW Automation and Technical strategy)

Utilization might be in conflict with certain quality objectives due to the fact that a high level of utilization implies less time for quality assurance, as less amount of time and/or people indicates that less time can be spent on controlling and supervising of quality. Investment is contradicting ergonomics as lower levels of investments indicates less resources that can be spent on the assemblers and operators. Availability is contradicting Square meters as too compact processes might create a lot of unavailability at breakdowns, due to difficulties of reaching the affected parts. Finally, Manufacturing cost per car depends not only on investment, jobs per hour nor square meters, but also on the specific location and kind of project location. As different project locations have different salary levels and different prerequisites, the KPI needs to be aligned with used strategies.

Continuously, the KPIs is not necessary contradicting against each other, but rather against certain Measurables, strategies and objectives. Considering this, it can be noticed that this is highly a question of trade-offs. The organization either has to find a way weighting the KPIs and Measurables against each other, or revising their current objectives or strategies in order to see which conflicts that can be solved.

To summarize the problems related to the design phase identified in 5.4.1 and from the Problems & Needs Analysis, the list below shows the most critical areas:

1. Lack of relevant comparisons
    - Lack of targets for all KPIs

- Lack of historical data for all KPIs
- Difficulty to compare the KPI results (especially manufacturing cost/car, investment and square meter)

2. Lack of proper definitions
    - Unclear division/definition between KPIs and Measurables, and how they are related
    - Manufacturing cost per car doesn't cover all relevant aspects (misses out on man-time, indirect manning, logistics and energy consumption costs)
    - Investment is difficult to estimate (how to cope with investment changes during time, and divide between type-bounded or not)
3. Not always possible to affect the end-result
    - Investment is difficult to affect due to different requirements for plants in different countries
4. Difficult to know how to prioritize
    - Not knowing which KPI to focus upon and how to handle trade-offs between the KPIs (different apprehensions of which KPI that is most important)
5. Some KPIs are contradicting Measurables, Objectives or Strategies

Further, there exists gaps in the apprehension between which KPI that is most important, and some potential performance objective areas (Quality and Human dimensions) where KPIs today are missing.

6.3.2 Implementation

Considering the lack of understanding for certain PMs, either it has to be confirmed that the current set are suitable for its purposes, and communicate out why that is the case, or consider if they should be removed and/or replaced.

To summarize the problems related to the implementation phase in 5.4.1 and from the Problems & Needs Analysis, the list below shows the most critical areas:

1. Lack of understanding
    - Lack of understanding of the purpose of all the PMs (especially for the KPI 'Squaremeter' and Measurable 'Amount of robots')
    - Lack of understanding of how to use the PMs
2. Lack of time for education
    - Not enough time spent for learning how to use the PMs

6.3.3 Usage

The issues raised in section 5.4.3 relates not only to the lack of some kind of database (something which also was highlighted from the IDEF0 analysis in 5.4.1), but also to the lack of feedback and comparison between processes described in 5.4.1. Further, other interviewees, especially engineers, stated that they had trouble finding up-to-date PMs, something that is also connected to both the areas of centralization as well as communication.

Concluding from the present situation, something that should be considered during the data collection phase is the development phases of a car program (see chapter 4.2) in relation to certainty; as more and more technical specifications are set and determined, there is an increasing level of certainty for each milestone that is reached. This also means that the longer the development phase has come, the more can be measured as the data gets accessible. During the development phase there is always a level of uncertainty of the data, since it is a work in progress. This level of uncertainty is visualized in figure 6.3.

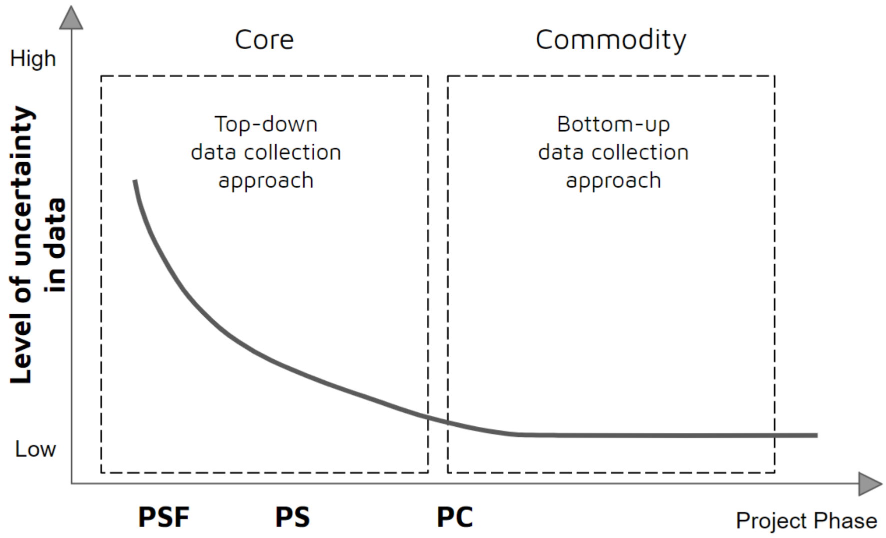


Figure 6.3: Uncertainty with data during the different phases

In the very early phases a top-down data collection method must be used, and data is generally though estimations and (educated) guesses. Later, a more bottom-up oriented data collection - through raw data derived from simulation programs - can be performed. This uncertainty in data collection, and the fact that data is collected from phases which both have high and low levels of uncertainty, causes problems in the actual calculation; should the average value be used? Or a snapshot at a certain gate? What is the correct approach? As the data is gathered continuously during the projects, the uncertainty in data collection can cause troubles when the results later should be evaluated.

To summarize the problems related to the usage phase in 5.4.3 and from the Problems & Needs Analysis, , the list below shows the most critical areas:

1. Lack of standardization of data collection methods
2. Lack of centralization
    - No system or database to store the PM data in
    - Lack of knowledge of which PMs that are up-to-date
3. Time-consumption

    - Takes a lot of time to calculate the PMs
    - Takes a lot of time to understand how to report the PMs
4. Uncertainty of data
    - Difficult to know in which phase(s) the data collection should be performed (snapshot or trend-related)
5. No defined process for how the KPI results should be used or analyzed after they are reported.
6. PSR is not a good enough reporting system
    - Not possible to use the results for evaluation (not suitable colour system and lack of targets)

6.3.4 Revision

The current revision process has been conducted without any major issues, though the biggest problems is currently related to the lack of strategic alignment into the revising process. In the next chapter follows a deeper analysis of this.

6.4 Strategic Alignment Analysis

As mentioned in both chapter 3.1 and 3.2 it is very important that PMs are aligned top-down from overall corporate strategy, bottom-up from operation (in this case; running production) as well as being vertically aligned with other departments. The following section evaluates current PMS in these aspects.

6.4.1 Vertical alignment:

As previously mentioned, employees have troubles with understanding the purposes' of current PMs; their roles, why they should be used and so forth, something that affects the criteria "understandable" and "support" according to table 6.1. In the long run, this implies that alignment in term of communication from Top Management is inadequate, especially when it comes to communication and information about lean principles (for instance; why Square meter is an important KPI), as well as clarity of directives.

It also became clear from the interviews that communication neither about higher-level KPIs (the ones M&L uses to measure present performance in the Plants) nor lower-level KPIs (the ones that the Plant uses to measure plant performance) had been communicated to BIW. Considering that BIW (Core in particular) is responsible for the design and revision of KPIs, it is by means a problem as the communication channels to ensure PM alignment consequently are closed on a vertical alignment level.

With regard to identified lack of alignment with running production, this also affects the management of current PMs. For instance, one engineer expressed it like this:

> *"How can we get better and set relevant KPI targets if we don't know current state of running production? I have no idea how current performance are of my processes"*
>
> — Engineer BIW

This is highly connected to the problems identified in chapter 5.4.1 and 6.3.1, where the lack of KPI targets is a source of frustration. Overall, the absence of knowledge about current state in running production was announced by both Top Management, Managers and Engineers as a problem, along with the difficulties with getting the "right" kind of data, due to different ways of measuring between the people at the plants. This was also highlighted from the interviews where one interviewee stated that:

> *"Often we just get a picture [from top management] of a whiteboard with a drawing, that doesn't feel serious"*
>
> — Engineer BIW

According to Almström et al. (2017) it is important to create understanding and motivation in a strategy deployment process in order for it to be successful. This is an area where it is important for the organization to improve. The lack of this kind of vertical alignment does not only affect communication and understanding of current PM's, it was also discovered that other components, closely related to the PMS and how the PMs are perceived, was affected:

- 2020-targets - lack of understanding of how the objectives affects BIW, and how current PMs is related to these objectives
- Ideal state - different perception of how to interpret the role of an ideal state, and how this is related to the PMs

Both the 2020-targets and the ideal state concept have - or at least should have - a high impact of current PMs. When it comes to the purpose of ideal state (in BIW's case does the ideal state refer to an ideal state of production processes and layouts), the perception is rather aligned from top management down to engineering level: The most common apprehension is that the ideal state should help them to align peoples thinking, standardize layouts between plants and help them to reach the 2020-targets. This is rather aligned with the KPI purposes' described in chapter 5.2. Though, when it comes to the ideal state's "level of reachability", in terms of when this state should be able to reach, a gap could be identified:

Most Managers and Engineers considers ideal state as something that is "not reachable today", and rather something that can be reached within 5-15 years:

Perception concept 1: Ideal state is a rather "fluffy" long-term vision

Top Management on the other hand, sees ideal state as something that is reachable already today:

> *Perception concept 2:* Ideal state is something that should be implemented today at greenfield projects

The different perception of when the ideal state should be reached is somehow troubling, as the intention of an ideal state concept is to help engineers and managers in the planning process of new layouts. Having different apprehensions on how and when the ideal state should be possible to reach, gives different conclusions on how to approach future layouts. It is clear that this difference causes a gap at BIW.

6.4.2 Horizontal alignment:

In terms of horizontal alignment, it can be concluded from the discussion above that one of missing alignments exists on a global level, as there does not exists any standardized way of measuring between plants. In the long term, this is the root cause to some of the data collection uncertainties described in section 6.3.3.

An area which is not considered in current PM context at all, is alignment with P&Q. As explained in 4.1.1 P&Q is one of total two main intersections which BIW is collaborating with (where the other is Plant). Considering the strong connection between the two departments it is important to also align PMs between these two areas. This is also emphasized by Wiktorsson et al. (2018) as an important matter for enabling indicators in early production development phases.

Further, it was revealed from the interviews that no alignment is today conducted within the other departments that also have developed their own sets of PMs. Based on the fact that the PMs were developed on the same premises, and with the same aims, it can be concluded that the KPIs should be aligned and support each others, especially as it was highlighted that some other departments have contradicting KPIs towards BIW.

Finally, internal alignment within BIW is something that also should be considered, especially considered the different perceptions identified through e.g. which KPI that is most important, how to use them etc., but also in consideration to other steering documents and guidelines such as Automation strategies, Technical strategies, Manufacturing Guidelines and so forth.

6.4.3 Summarizing current alignment problems

To summarize the problems related to alignment, the list below shows the most critical areas:

1. Lack of vertical alignment
   - Lack of alignment from M&L about the PMs they are currently using for assessment of Plant performance
   - Lack of alignment from M&L about how BIW should perceive and adopt Lean Principles, 2020-targets and Ideal State

- Lack of alignment with running production about the PMs they are currently using for assessment of Plant performance, including current performance.
2. Lack of horizontal alignment
- Between BIW and P&Q
- Between BIW and other ”sibling” departments (e.g. Stamping, Paint and Final Assembly)
- Within BIW internally

Taking the discussed areas above into account, the current situation can be visualized according to figure 6.4, where current communication, information channels and feedback-loops are highlighted with respect to identified problems (marked with a black cross) and working procedures (without cross).

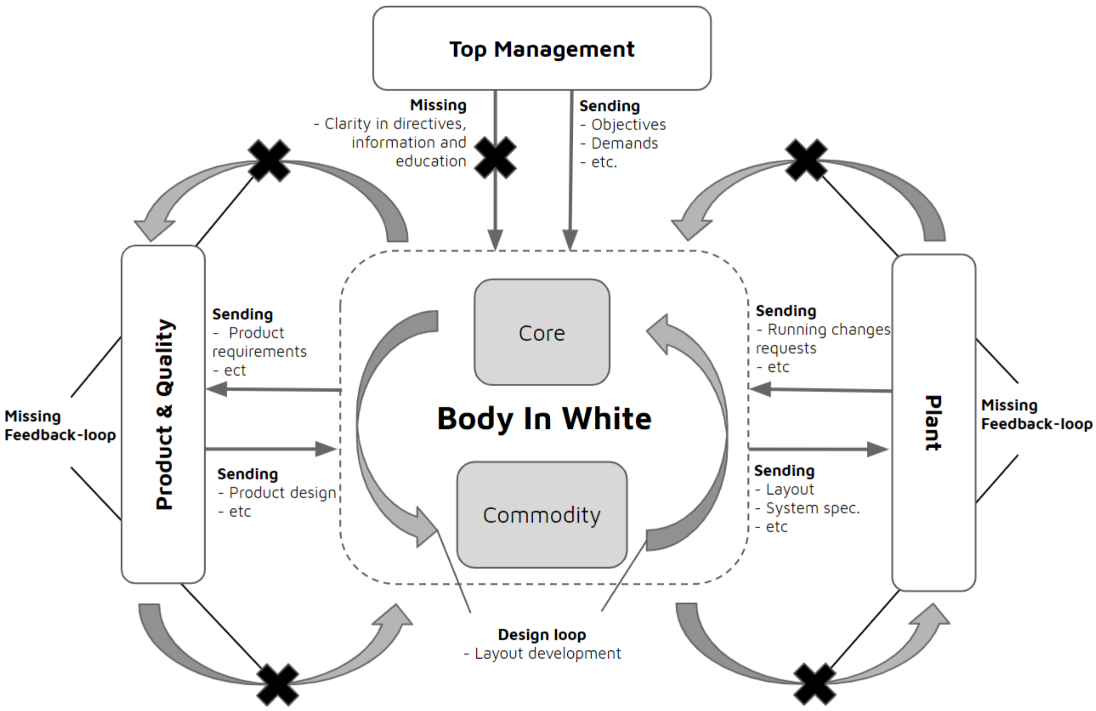


Figure 6.4: Information and communication flow regarding PMS: Some issues

6.5 Possibilities with new technologies

Based on observations and the data from the interviewees it seems that BIW currently seems to be at the first stage of the Industrie 4.0 Maturity Index by Schuh et al. (2017), as can be seen in figure 3.11. According to (Schuh et al. 2017) the first step of Digitalisation and the way to Industry 4.0 is the Computerisation phase, where it is common that different information technologies works separately in isolation from each other in the organisation. This seems to be the case currently at BIW, with many different systems and data bases with information that are not connected.

Relating Industrie 4.0 to future possibilities, it can be emphasized that the concept should be seen as a ”value-adding” feature for the future, when the organisation goes from ’good’ to ’excellent’. This is supported both by the the 4-stage model described in section 3.4.1 and by Top Management’s opinion.

7
Present state: Summarizing the effects

In the following section the major findings and conclusions are summarized related to present state.

7.1 The effects of having Performance Measurements in a early development phases

Having KPIs in early production phases has showed having a rather large impact on the organization and how they work, both considering decision-making and how top management reviews current performance. Three major challenges related to KPI usage in early phases was described in chapter 3.2.3 by Wiktorsson et al. (2018):

- Challenges of understanding the purpose of specific KPIs
- Lack of data and information about yet not established manufacturing systems
- Lack of link or flow between KPIs in the different lifecycle phases towards the operational stage

According to the findings, all these three areas was emphasized as especially bothersome for the organization by the interviewees. Alignment is one area especially highlighted, as the PMs does not only needs to be aligned horizontally but also vertically, something that creates big demands on the organisation.

Several problem-areas have been pinpointed, but there are also many positive aspects that is related to having PMs in early production development phases, especially when it comes to the purpose ”guiding” - the PMs have big potential of driving right kind of behavior of the employees. Further, it can be concluded that KPIs in early stages have additional requirements, besides from the ones described in section 3.2.2:

R1: The KPI should work both for greenfield and brownfield projects

R2: The KPI should be applicable on a global level, for all plants

R3: The KPI should have different targets for different countries/plants, based on local conditions (e.g. strategies and salary levels)

Moreover, it is important to emphasize how closely related PMs are to the actual manufacturing strategy in early production development phases - given that the PMs on the highest purposely level are there to guide and drive, the PMS can be seen as the enabler and guide of the manufacturing strategy, stretching the strategy into action through performance measurements.

The implementation of current PMs has taken two years, something some interviewees have been troubled about. Though, it is important to understand that implementations of PMs takes time, according to McKinsey&Company (2019) does it ”usually take between one and two years for a new performance-management system to become a cultural norm, and another three to five years for it to be fully embedded with all other business systems”. Continuously, the time span that BIW and Volvo have performed ’implementation’ is fully normal and what can be expected being a normal implementation phase.

7.2 Main findings: Major improvement areas

The main improvements that has been identified from the interviews and discussed areas above have been summarized and categorized into 6 major improvement areas:

1. Communication
2. Alignment and Feedback
3. Education and knowledge of Lean
4. PMS structure
5. PM structure
6. Data systems

The first improvement area derived from the analysis is *Communication*. The stakeholders that mainly has expressed issues regarding communication are Managers and Engineers. The main sub-areas for improvements regarding Communication can be seen in table 7.1.

Table 7.1: Improvement area 1 - Communication

Improvement area 1 - Communication	
Communication regarding:	**Stakeholder that identified the problem**
- the purpose of PMs and how to use them	M, E
- explainations of certain PMs and the process of them	M, E, PRM
- channels between Plant (running production) and ME	M, E
- other departments PMs and PMS routines	M, E
- how Top Management choose to send information	E

The second improvement area derived from the analysis is *Alignment and Feedback* and the associated sub-areas can be seen in table 7.2. All stakeholders except the Program Managers has identified Alignment as an important improvement area. The alignment refers to both the handling and explanation of KPIs as well as alignment with BIW internally and towards other department.

Table 7.2: Improvement area 2 - Alignment and Feedback

Improvement area 2 - Alignment & Feedback	
Alignment and Feedback between:	**Stakeholder that identified the problem**
- BIW and other departments, both vertical and horizontal	TM-ME, TM-BIW, M, E
- PMs and work documents, objectives and strategies	TM-ME, TM-BIW, M, E
- how PMs should be measured globally	M, E
- BIW internally, management to engineers	M, E

The *Education and knowledge of Lean* is the third improvement area and this area has been identified by both Top Management as well as Managers and Engineers. The related sub-areas can be found in table 7.3. Some of the Engineers have expressed that they have not got the support or coaching required. Further, as one interviewee states it:

> *"We need to implement more lean fundamentals"*
>
> — Top Management BIW

Table 7.3: Improvement area 3 - Education and knowledge of Lean

Improvement area 3 - Education and knowledge of Lean	
Lean principles, to:	**Stakeholder that identified the problem**
- not have right knowledge, education and enough coaching time	TM-ME, TM-BIW, M, E
- not focus on the right problems	TM-ME
- not have the same perception about Ideal State	TM-ME, TM-BIW, M, E
- not enough time for implementation and learning purpose	E

The fourth improvement area that can be derived from the analysis is about the *structure of the PMS* and the sub-areas can be seen in table 7.4. Some of the issues that has been expressed from the interviewees is that many of the activities related to the PMS are time consuming, such as gathering data and there is also no clear definition of the current PMS.

Table 7.4: Improvement area 4 - PMS structure

Improvement area 4 - PMS structure	
PMS structure is:	**Stakeholder that identified the problem**
- not handling conflicts between objectives, strategies and PMs	TM-BIW, M, E, PRM
- lacking clear connection to 2020 targets	TM-BIW, M, E
- time consuming	TM-BIW, E
- missing feedback-loop from Top Management and other departments	TM-BIW, M
- lacking a system view	TM-BIW
- missing responsible person for the PMS	M
- missing targets for certain PMs	M, E
- missing stardards for collecting and reporting the PMs	E

The fifth improvement area that the interviewees has identified relates to the measurement and *PM structure*, and the sub-areas can be seen in table 7.5. Some of the problems that the interviewees has expressed is that they do not understand the purpose with the KPIs, that the KPIs are difficult to calculate.

Table 7.5: Improvement area 5 - PM structure

Improvement area 5 - PM structure	
PM structure is:	**Stakeholder that identified the problem**
- not showing the purpose of the PMs	TM-ME, TM-BIW, M, E
- missing breakdown of KPIs	TM-ME
- missing location of PM data	E
- difficult to compare measurement data with values, projects and running production	TM-BIW, M, E
- not clearifying how to measure the PMs	E
- missing PMs, such as people performance and quality	TM-BIW, M, E
- missing PM definitions	M, E

The seventh and final improvement area that can be derived from the interviews refers to the *data system*. Interviewees stated that they are missing a common data base or system to store the data for the PMs or that it is difficult to get data from the plant (running production). The improvement sub-areas can be found in table 7.6.

Table 7.6: Improvement area 6 - Data system

Improvement area 6 - Data system	
Data system is:	**Stakeholder that identified the problem**
- missing a central common system to store PM data	TM-BIW, M, E
- difficult to get data from running production	M, E
- missing data to motivate certain decisions	TM-ME, TM-BIW, M, E
- not up to date and needs a feedback-loop-	TM-BIW, M, E

7.3 SWOT-analysis

To give total picture regarding current situation at BIW and thus summarize the identified strengths, weaknesses, opportunities and threats of current PMS, a SWOT-analysis was performed and can be seen in figure 7.1.

Note that ”opportunities” consists of the identified PM purposes and that ”weaknesses” consists of the six improvement areas. ”Strengths” and ”Weaknesses” consists of other identified areas from the findings and analysis.

Strengths	Weaknesses
Internal strengths regarding working with the PMs:	*Internal weknesses regarding working with the PMs:*
The KPIs have helped changing focus from investments towards **more long-term targets**	Problems regarding **communication**, both vertically and horizontally
Strong and sound **company improvement culture**	Problems regarding **alignment and feedback**, both vertically and horizontally
Suitable technical environment with the **right competences**	Lack of education and knowledge about **lean**
A lot of interest and **overall positive picture** of the usage of the PMs	Problems related to the **PMS structure**
People find **current PMs good** and relevant for its purposes	Problems related to the **PM structure**
Documentation of calculation formulas and definitions exists	Lack of a good enough **data system**

Opportunities	Threaths
Working with the KPIs and Measurables can help:	*Things that can threathen the usage of a KPIs and Measurables:*
Driving quick and straight development towards fulfilment of current targets	**Contradicting KPIs** between departments and units
Controlling progress and **giving feedback** that development is going in the desired direction	**Working towards different targets** - Gap between management of which targets that should be focused upon, and with the KPIs that employees are currently working towards
Supporting the **decision-making processes**, to take decisions based on facts	Taking **a lot of time** to work with the PMS (finding and working with the KPIs)
Help to **explain** [to management] why certain decisions needs to be taken	Taking the **wrong decisions from not updated data**
Reporting progress [to management] in relation to targets, time and between projects	Too **complex PMS structure can hinder the work**

Figure 7.1: SWOT-analysis

8

Future state: Solutions

This chapter explores possible solutions and interventions in order to improve current state.

8.1 Strategies to ensure future performance

Based on the SWOT-analysis a TOWS-analysis was conducted, and through this combining identified strengths, weaknesses, opportunities and threats into strategies, in order to gain possible solutions for the identified problem. The TOWS-analysis can be seen in figure 8.1.

	Opportunities	Threaths
Strengths	**STRENGTH-OPPORTUNITIES STRATEGIES** *To maximize opportunities using strengths:* (A) Define a Performance Measurement System, derived from current KPI usage: How to use handle the entire KPI lifecycle (B) Set targets for all KPIs (C) Investigate identified PM conflicts and align (D) Standarise data collection methods	**STRENGTH-THREATS STRATEGIES** *To minimize threat using strengths:* (E) Look into KPI alignment with other departments, both vertical and horizontal: P&Q, Running Production, Final Assembly, Paint, Logistics etc. (F) Make sure that the KPIs are aligned with corporate strategy: Revise, and possible add KPIs and Measurables, based on a top-down approach with bottom-up capabilities
Weaknesses	**WEAKNESSES-OPPORTUNITIES STRATEGIES** *To minimize weaknesses using opportunities:* (G) Clarify all KPIs and Measurables purposes and definitions (H) Allow more time for PMS education: Clearly communicate out purpose and usage to employees (I) Develop a database for centralisation of KPI information and results (J) Develop a tool for decision making of production layouts	**WEAKNESSES-THREATS STRATEGIES** *To minimize weaknesses to avoid threats:* (K) Better and more communication from top management down to engineering level (for alignment of objectives, strategies and targets) (L) Better and more communication between the plant and ME (for being able to follow up performance in the plant)

Figure 8.1: TOWS-analysis including guidelines for managing the PMS

In this thesis, it has been chosen to further focus on the alternatives A - *Define a new PMS*, F - *Alignment of KPIs with strategy to remove existing and/or find new potential KPI-areas*, I - *Develop a database* and J - *Develop a tool for decision* *making* (on a conceptually high level), and partly on alternative G - *Clarify KPI and Measurables*.

Alternative B (Set targets for all KPIs), C (Investigate identified PM conflicts) and D (Standardize data collection methods), H (Allow more time for PMS education), K (Better and more communication from Top Management), and L (Better and more communication with Plant), is mainly referring to internal capabilities that needs to be strengthened within BIW. Further, alternative E (Alignment with other departments) is recommended to be a future investigation, with a deeper analysis in that field. Continuously, these points constitutes the guidelines for BIW.

In the section below follows a suggestion, based on the findings and analysis from the previous chapters, of a new PMS including models to ensure future performance.

8.2 New PM structure

Given the improvement area ”PM Structure”, a new presentation of PMs is suggested, in order to simplify and clarify definitions and divisions. The suggested new PM structure can be seen in table 8.1, where each KPI and Measurable are grouped together, related to a specific Performance Objective and a relatable short- or long-term target. Note that the structure is using the four performance objectives areas from the Operations Strategy Matrix, including the World Class Manufacturing from section 3.4, with one additional area; Safety.

Table 8.1: A suggestion of how to structure the Performance Measurement

PRODUCTION DEVELOPMENT PERFORMANCE MEASUREMENTS						
		Level	Performance Measurements	Unit	Purpose	Formula
PERFORMANCE OBJECTIVES	DELIVERABILITY	**Target 1**				
		Result-KPI				
		Process-KPIs				
		Measurerables				
	COST	**Target 2**				
		Result-KPI				
		Process-KPIs				
		Measurerables				
	QUALITY	**Target 3**				
		Result-KPI				
		Process-KPIs				
		Measurerables				
	FLEXIBILITY	**Target 4**				
		Result-KPI				
		Process-KPIs				
		Measurerables				
	SAFETY	**Target 5**				
		Result-KPI				
		Process-KPIs				
		Measurerables				

As seen in the figure consist the division of *Result-KPIs*, *Process-KPIs* and *Measurables*. In regards to the identified KPI purpose areas and that KPIs can be either by leading or lagging type (see more about this in section 3.2), the following structure is recommended:

- Result-KPI: The actual outcome connected to relevant target ('lagging')
- Process-KPI: The most important Performance Measurement (a ratio), drives strategy ('leading')
- Measurable: Not a part of the KPI formulas, but gives additional dimensions

Further, the following clarification of PMs is suggested for BIW to follow, in order to standardize the PM division:

- *PI (Performance Indicator)*: Performance Measurement (a ratio)
- *I (Indicator)*: Sum of elements OR More important building block
- *E (Element)*: Building block

The suggested PM division is developed with regards to the the KPI criteria stated in section 3.2.2, that is based upon standard ISO/DIS:22400-1 (2013), the handbook by Almström et al. (2017) and article by Neely et al. (1997). Continuously, a KPI is build up upon PI:s, I:s and E:s. Measurables are by definition separate Performance Measures which is not included as a part of the KPIs, but instead to give additional dimensions, and can continuously be a PI, I and/or E.

8.3 A model for connecting KPIs with Operational Excellence

One of the main findings from present state was the lack of understanding of current KPIs, their role, purpose, function and connection to BIW's operational Excellence journey. Also considering the two improvement areas "Communication" and "Alignment and feedback", it is clear that a better way of communicating and presenting the PMs' role are needed. This is partly solved by the new division described in section 8.2, where the role of the different PMs are defined, but there still exists questions related to how the PMs should be defined in relation to current Operational Improvement journey.

Based on the findings from the present state, with concern to the different apprehensions regarding ideal state, the current lean transformation with the vision to become "Best-In-Class", and pressure for achieving Industrie 4.0, it can be concluded that there exists a lot of different objectives and visions of what is aimed to be achieved, as well as many perceptions of what these visions really indicates. The majority of Volvo's efforts, such as the development of the KPIs, the overall transformation and the long-term targets, relates to the matter of operational improvement. Current issues suggests that a new approach for understanding this operational journey is needed. Because in which light should the PMs, with emphasis on the KPIs, be seen?

To be able to answer this question was a model developed, which can be referred to as an "Operational Excellence and KPI connection model", see figure 8.2.

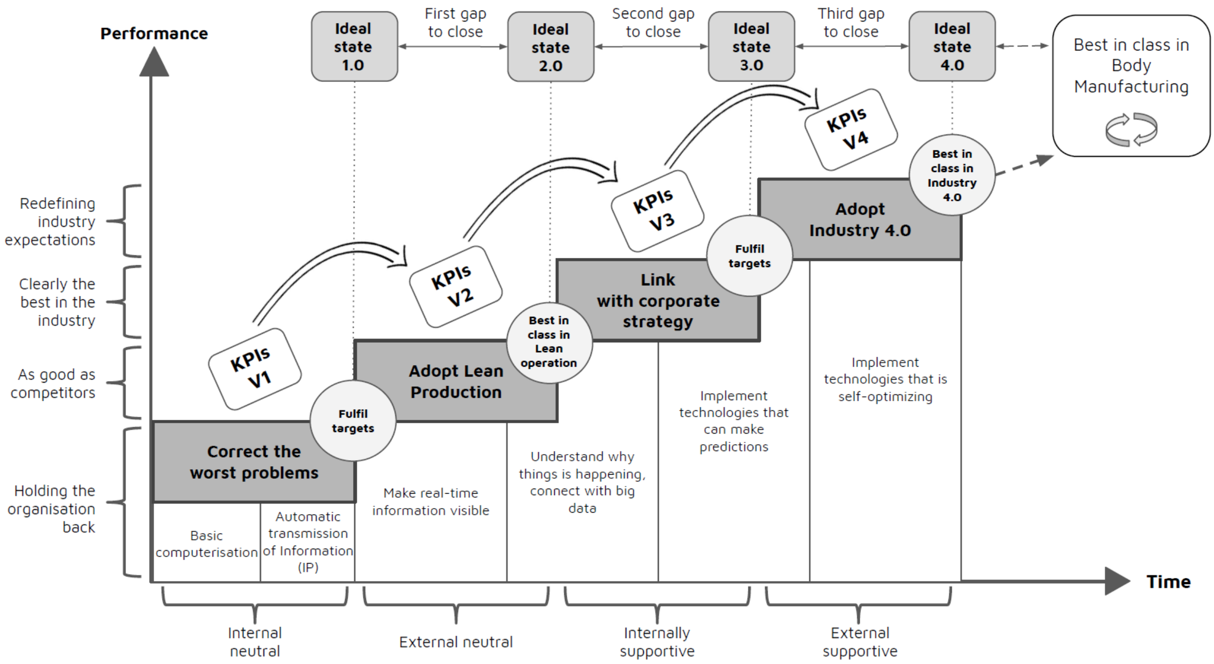


Figure 8.2: A suggestion of model for approaching operational improvement with Industry 4.0, ideal state and corresponding KPIs

As described in section 3.3.1 it is important that the chosen set of KPIs should be the ones that have largest impact on the organization's effectiveness, with regards to achieving higher-level business goals. Relating this to the operational improvement model in section 3.4.1, and the fact that KPIs needs to be continuously revised (as described according to the KPI lifecycle in 3.1), the model could be developed such as it does not only take the KPIs, ideal state and operational improvement into consideration, but also how the journey towards Industry 4.0 relates to these steps (according to the Industry 4.0 Maturity Index from chapter 3.5).

The model is developed according to have a general approach, and different organizations can accordingly start on different steps of the "stair", as seen in figure 8.2. Note that the operational improvement step "Best Practices" has been replaced with the label "Adopt Lean Production", due to the fact that lean principles is being considered being a manufacturing best practice (Laugen et al. 2005)(Krafcik 1988)(McKinsey&Company 2014) In the same way, "Give an operations advantage" is replaced with "Adopt Industry 4.0", due to the findings from 6.5.

Consequently, it important to understand that the current set of KPIs should be the ones that helps guiding the organization towards a specific ideal state, a state which is defined by a certain set of targets and/or best-in-class objectives. The general vision of being "Best-In-Class" is always evolving, as new technologies and best practices appear, and the general approach is consequently to work towards different stages of best-in-class.

In Volvo Cars case, the overall lean transformation suggests that they are in the ”KPI V2”-box. The target is accordingly to become ”best-in-class” in lean operations, a target which is achievable today by using right kinds of practices and resources. The KPIs should therefor help guide BIW towards primarily fulfilling the 2020-targets, but also help them to become ”best in class in lean operations”, compared to competitors. The matter of integrating Industry 4.0 techniques should for the moment be focused upon making real-time information visible.

8.4 A model for KPI identification

Something that has been highlighted throughout this report, is the importance of aligning KPIs with strategy. In order to see if current KPIs is aligned with strategy and to identify potential missed areas was a model developed according to figure 8.3.

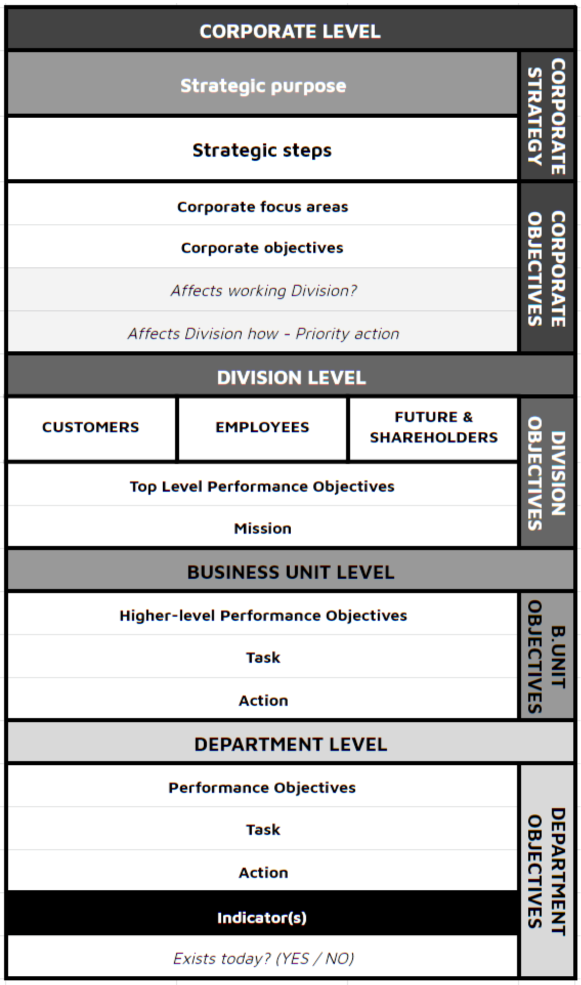


Figure 8.3: KPI Breakdow Tree: Corporate strategies into departments PMs

According to Wiktorsson et al. (2018) is one of the main challenges for the use of enabling indicators to find a ”balanced evaluation in early phases”, meaning that current KPIs should be considered in a multifunctional perspective. Considering this, the model is built upon the basic principles of the balanced scorecard (describes in 3.4.4), into a kind of ”tree structure” which is a suitable way to organizing the KPIs, in order to see performance through a operational, tactical and strategical perspective. Similar types of objective breakdowns have been described by Ante et al. (2018), Neely et al. (1997) and others, as well as being observed as a part of manufacturing strategy formulation (as a breakdown of required performance objectives, visualized in chapter 3.4.3).

The highest level, *Corporate Level*, consists of two big areas where the strategic purposes and related steps are defined. For instance, this could for instance be a corporation’s main strategy of e.g. ”Sustainability” as strategic purpose, and ”Sustainable Products” and ”Sustainable Business” as strategic steps. Corporate focus areas relates to what they want to achieve, e.g. ”Become best-in-class of sustainability” and corporate objectives what this indicates on a more detailed, target-related level, e.g. ”Be climate neutral by 2030”. Finally, these objectives are evaluated by question yourself rather it affects lower-level division, and in which way. For instance, this could mean that there exists a ”need for reducing energy consumption”, and thus indicating preliminary decision areas.

The next level, *Department Level*, shows how identified areas from the corporate level are linked to the three main areas ’Customers’, ’Employees’ and ’Future Stakeholders’. Top level performance objectives refers to the areas which affects the division, derived from breakdown above. This could for instance indicate ”Environment”. The mission area tell in which way the division should fulfill the corporate objectives (and might continuously be the same priority action as described above, or differ).

The breakdown of performance objectives and related targets are further broken down into *Business unit level* and finally into *Department level*, depending on how the hierarchy looks like of the specific organisation. similar to before are higher-level performance objectives broken down into more quantifiable and narrow areas. Task relates to needed arrangement in order to fulfill the performance objective, and action an even more detailed description of ’how’. For instance, Environment might be broken down into ”Reused machines” and ”Energy consumption”, with corresponding tasks of ”Increase amount of of reused machines” and ”Minimize amount of robots”. Finally, it can be evaluated whether there exist a PM for the identified area, or not.

In order to identify the most critical Performance Objectives it is important to identify the most critical performance objectives that is important for achieving next ideal state, as discussed in 8.3. Through this, it is possible to pinpoint which PMs that should be considered suitable KPIs, of all PMs identified.

8.5 Applying the models on BIW

In order to further evaluate BIW's current PMs, the KPI breakdown tree was used as seen in figure 8.4. Consider the importance of having both a top-down as well as a bottom-up approach (as described in chapter 3.4.2), the model used the Volvo Cars' annual report as input for corporate level, and the findings from the interviews as inputs for lower levels; from Top Management level down to Engineering level. Important to highlight is that as M&L is responsible for not only ME but also the Plants, this indicates that an alignment with M&L also indicates an alignment with the Plants, as it is ML which analyses current Plant performance (on a higher level).

Further, the final inputs is supported by basic lean principles, in order to provide answer on the practical question on ”how” - indicating the practical ’action’ required from BIW in order to achieve the identified Performance Objectives. The full analysis, where Volvo Cars' corporate strategy are broken down into KPIs on a detailed level, can be found in Appendix C.

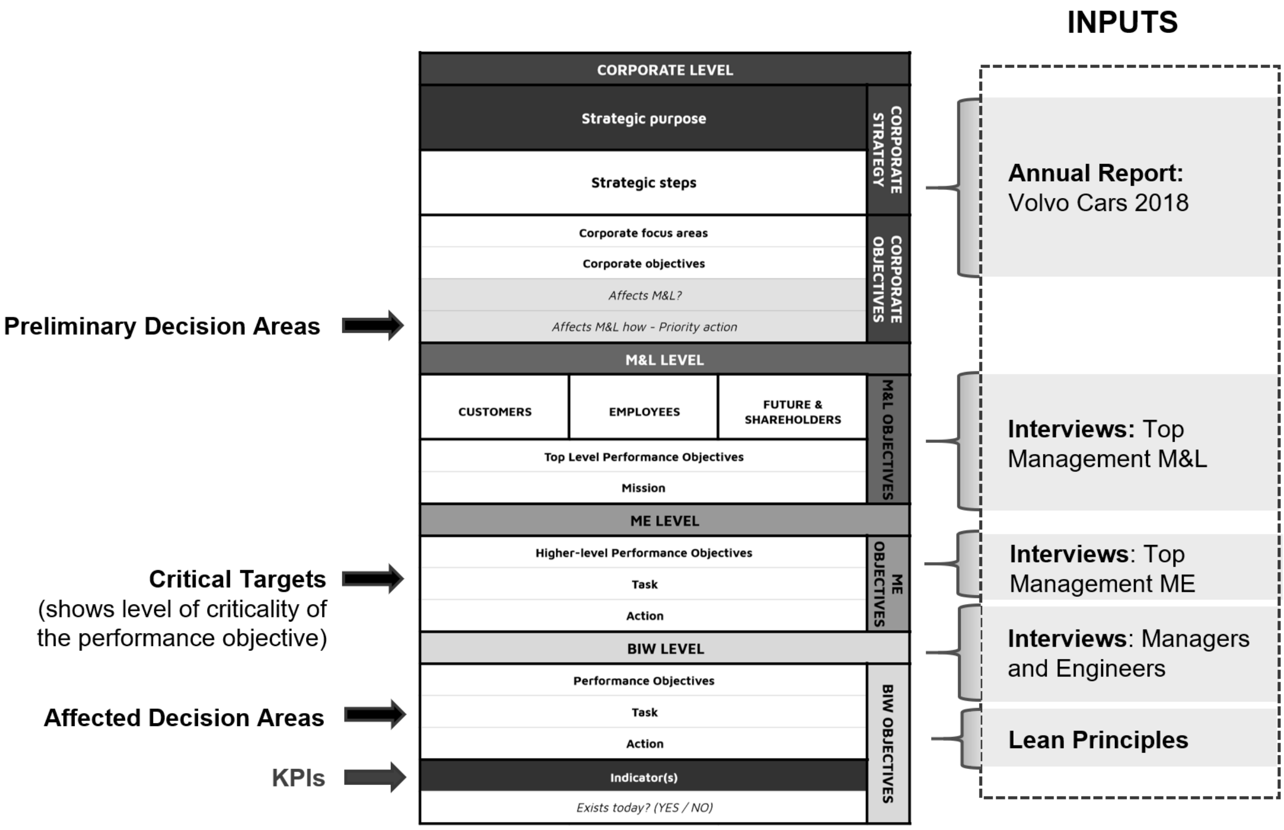


Figure 8.4: Breakdown of corporate strategy into performance objectives for BIW

8.5.1 Different sets of Performance Measurements

Given the findings from present state and the analysis from figure 8.4 and Appendix C, it can be concluded that there exists several potential sets of KPIs that can be used for organizations in early production development phases, all related to identified purposes and the function as ”enabling indicators”, but with minor differences:

1. Production Development PMs - used for decision-making and controlling of production layouts and processes and their progress
2. Project Progress PMs - used for follow up progress of projects
3. People Development PMs - used for follow-up progress of the internal work performed at BIW

The PMs that BIW currently has, would consequently belong to the ”Production Development” group. By dividing the PMs in different groups, it is expected to be more manageable for employees to understand the purpose of the PMs, and how they should relate to them. Further, given that BIW is a rather larger organisation with many different subgroups with different objectives, it can be discussed if one set of PMs - especially with respect to the Production Development PMs - is enough. The different subgroups within BIW, Core, Commodity Product, Commodity Plant, Tooling & Equipment et.al., has all different objectives and deliverables, and having one common set of PMs can consequently become a challenge. Thus, investigating possibilities of diversifying sets of PMs is suggested.

8.5.2 Missing Performance Measurement areas

Further, from the analysis performed in figure 8.4 and Appendix C, the following conclusions could be drawn:

- All current KPIs is related to some kind of performance objectives that is important for the organization.
- Manpower Flexibility is, if any, the KPI that is less related to the most critical business targets (2020-targets)
- Ergonomics, Safety, Geometry Assurance, Machine Maintenance and Pull Principle are five areas which is not being considered as KPIs today, but which is important for short-term business targets (2020-targets). They are suggested to be investigated as potential KPIs.
- More areas was identified as important to corporate strategy but less important to short-term targets;
  - *Energy*-related KPIs, such as Energy consumption and Reused machines
  - *People progress*-related KPIs, such as Gender Equality and Work Efficiency
  - *Flexibility*-related KPIs, such as Variant flexibility, Assemble type flexibility and Set-up/Take-down flexibility
  - *Reliability* and *Availability*-related KPIs

The full new suggested PM structure is seen in table 8.2. Grey colour (horizontally) colour indicates a new/adding PM, compared to current set. Further, the structure is following the recommendations from chapter 8.2. It can be notices that although some PMs have been added, the amount is still manageable and compact (with a total of 10 KPIs and 10 Measurables), something both Almström et al. (2017) and Allio (2012) states is important in order to have a manageable system (indicating that ”less is more” is a PMS context).

Table 8.2: New PM Structure

BIW PRODUCTION DEVELOPMENT PERFORMANCE MEASUREMENTS (PMs)							
Objective	Area	Group	Level	Performance Measurements	Unit	Purpose	Formula
PERFORMANCE OBJECTIVES	DELIVERABILITY	**2020-target#1 Lead Time**					
			Result-KPI	*Throughput time (lead time)*	*HH:MM:S*	*Report to management*	
		Key PMs	**KPI**	**Operator utilization**	**%**	**To increase operator efficiency**	**f (VA, NVA, NNVA, Cycle time)**
		Key PMs	**KPI**	**Machine utilization**	**%**	**To increase machine efficiency**	**f (Machine time, Cycle time)**
		Key PMs	**KPI**	**Line utilization rate**	**%**	**To increase line efficiency**	**f (VA stations, NVA stations)**
		Key PMs	**KPI**	**Machine maintenance** - recommended to be investigated			
		Supporting Measurables (M)	PI	Line technical availability (OPR)	%	To increase capacity / To explain process factors	f (Production time, Stop time, Net available time)
		Supporting Measurables (M)	I	Number of build steps	#	To explain product factors	f (Building steps)
		Supporting Measurables (M)	I	Number of articles per car	#	To explain product factors	f (Articles)
		Supporting Measurables (M)	I	Joining equivalent	#	To explain product factors	f (Joining equivalents)
	COST	**2020-target#2 Tied-up capital**					
			Result KPI	*WIP cost **(ADDED)***	*SEK*	*Report to management*	
		Key PMs	**KPI**	**WIP/Buffer related indicator** - recommended to be investigated			
		2020-target#3 Costs					
			Result KPI	*Manufacturing cost / car*	*SEK/car*	*Report to management*	
		Key PMs	**KPI**	**(Manufacturing cost/car)/sqm/JPH** (ADDED)	**SEK /sqm/JPH**	**To minimize costs**	**f (Investment, Field-type, Direct Manning at 100%, Project Location, Sqm, WIP cost, JPH,** Energy consumption, Logistics, Indirect Manning**)**
		Supporting Measurables (M)	PI	Automation ratio/level	%	To explain machine processes factors	f (Automated stations, Manual stations)
		Supporting Measurables (M)	PI	Customer demand	cars/year	To explain demand factors	f (Yearly volume, Net available time)
		Supporting Measurables (M)	I	Amount of F-packs (Robots)	#	To explain cost circumstances / To explain machine process factors	f (Robots)
		Supporting Measurables (M)	?	Product complexity - recommended to be investigated			
		Supporting Measurables (M)	?	Parts mounted outside of the plant - recommended to be investigated			
	FLEXIBILITY	Key PMs	**KPI**	**Manpower flexibility**	**%**	**To increase efficiency and minimize costs**	**f (Direct Manning at 100%, Direct Manning at 50%)**
	QUALITY	**2020-target#4 Quality**					
		Key PMs	**KPI**	**Geometry Assurance related indicator** - recommended to be investigated			
		M	?	Number of parts adjusted in C-factory - recommended to be investigated			
	SAFETY	**2020-target#5 Health and Safety**					
		Key PMs	**KPI**	**Ergonomic rate** (ADDED)	**%**	**To increase health level**	**f (Ergonomic green stations, Total number of stations)**
		Key PMs	**KPI**	**Safety rate related indicator** - recommended to be investigated			

BIW PROJECT PROGESS DEVELOPMENT PERFORMANCE MEASUREMENTS (PMs)				
Level	Performance Measurements	Unit	Purpose	Formula
Recommended to be investigated				

BIW PEOPLE PROGRESS PERFORMANCE MEASUREMENTS (PMs)				
Level	Performance Measurements	Unit	Purpose	Formula
Recommended to be investigated				

Given that many of current KPIs is dealing with target and comparison related problems (see section 6.3.1), some PMs had to be modified in order to solve the issue of relating "apples-with-apples". This refers to the KPI of 'Manufacturing cost per car', now defined as *Manufacturing cost per car/sqm/JPH*. Given that costs are (partly) driven by square meters and JPH (jobs per hour), a comparison using these as a ”divider” gives reasonable and fair comparisons between different layouts. Further, the KPI is suggested to be complemented with energy consumption-, logistics- and indirect manning costs in order to provide a complete picture of manufacturing costs, and to support other dimensions highlighted as important from the analysis.

Further, the following KPIs are suggested to be added:

- ”Ergonomic rate” - before only a Measurable, but now suggested as a KPI
- ”Machine maintenance related indicator” - suggested as a KPI
- ”Safety related indicator” - suggested as a KPI
- ”Geometry assurance related indicator” - suggested as a KPI
- ”WIP/Buffer related indicator” - suggested as a KPI

When it comes to missing Measurable, the developed model does not cover this kind of PMs. Though, based on the findings from the interviews, the following areas could be pointed out as currently ’missing’, but important areas when it comes to explaining and supporting the KPIs: *Product complexity* - gives an additional dimension of how the product complexity affects the production process, *Number of parts mounted outside of the plant* - gives an additional dimension of why certain KPI values differ between Plants, and *Number of parts adjusted in C-factory* - gives an additional dimension of possible ”false” KPI values, as parts sometimes are mounted in A-factory but adjusted in C-factory.

8.6 IT-solution: Database & decision-making

Having some kind of Performance Management System, an IT-solution for controlling PMs, is not uncommon among running operations functions, in order to control and evaluate current production performance (McKinsey&Company 2019)(Almström et al. 2017)(Eckerson 2009). Though, considering the different context of an early production development phase, the IT performance management system must be designed differently. For this purpose, a basic requirement list and process schedule have been developed, in order to serve as a basis for further development and evaluation.

Given the analysis and suitable solutions from the TOWS analysis, it become clear that the following attributes are missing related to an IT-solution:

1. A database for KPI storage
2. An decision making function
3. A controlling and feedback function
4. A dashboard function

8.6.1 Requirement List

The requirement list is divided by the identified functions, categorized into: Reporting, Controlling and Decision making. The importance of the separate requirements derives from the ”level of criticality”, in the Problems & Needs Analysis, from Appendix B. Below follows a brief description of the different functions, and the total requirement list for the IT solution can be seen below in table 8.3.

(1) Reporting function (input): Consists of the basic input data that is needed in order to fulfill the functions - the data which the database needs to be able to handle. Notice that this also includes the possibility of adding comments.

(2) Reporting function (output): Consists of the output functions, i.e. the needed dashboards.

(3) Decision making function: Consists of the actual layout suggestion that should be evaluated against other options. Notice that this also includes a balancing function.

(4) Controlling function: Consists of the chosen layout which results are compared against others in order to show performance progress.

Table 8.3: Requirement List for the IT solution

		What	In relation to	Importance (1-5)	Metric (including)	Purpose (why?)	"Customer"	"Producer"	Evaluation
1. Decision making function	1.1	**Current project**: Layout suggestion	**Current project**: Other layout suggestions	5	N/A	*In order to make a decision based on comparision with other layout suggestions*	N/A		**Pilot test**: Business Intelligence tool
	1.2		**Ideal plant**: Layout	5		*In order to make a decision based on comparision with ideal plant suggestions*			
	1.3		Target values	5		*In order to make a decision based on comparision with target values*			
	1.4	Balancing function		3		*In order to balance KPI values against each other*			
2. Controlling function	2.1	**Current project**: Chosen layout	**Same project**: Chosen Layout (through the project phases)	4	N/A	*In order to see progress and accuracy of KPI values through the project phases*	N/A		
	2.2		**Other projects (current)**: Chosen Layouts	3		*In order to show progress of KPI values compared to other current projects*			
	2.3		**Other projects (previous)**: Chosen Layouts	3		*In order to show progress of KPI values (compared to other projects) in relation to time*			
	2.4		**Running production**: Once implemented Layouts	5		*In order to show performance of KPI values calculated during planning phase with KPI values during running phase*			
	2.5		Target values	3		*In order to show progress of KPI values in relation to the project lifecycle*			

3. Reporting function (input)	3.1	**Current project**: Chosen Layout			- Current KPI values - Measurables			M, E	
	3.2	**Previous projects**: Layouts			- Current KPI values - Measurables			M, E	
	3.3	**Ideal Plant**: Layouts	N/A	N/A	- Current KPI values - Measurables	*Data inputs*	N/A	M, E	
	3.4	**Running production**: Layouts			- Current KPI values - Measurables			M, E	
	3.5	Target values			- Current target values			M	
	3.6	Comments			- Comments about the reported values			M, E	
4. Reporting function (output)	3.7	Progress-report	N/A	N/A	- Controlling function comparements	*Data outputs*	E, M	E	
	3.8	Result-report			- KPI results in relation to 2020 targets - Measurables		TM, M	E	

8.6.2 Process design

With respect to the requirement list was a simple process schedule developed, showing the basic information flow that should builds up the IT solution, seen in figure 8.5.

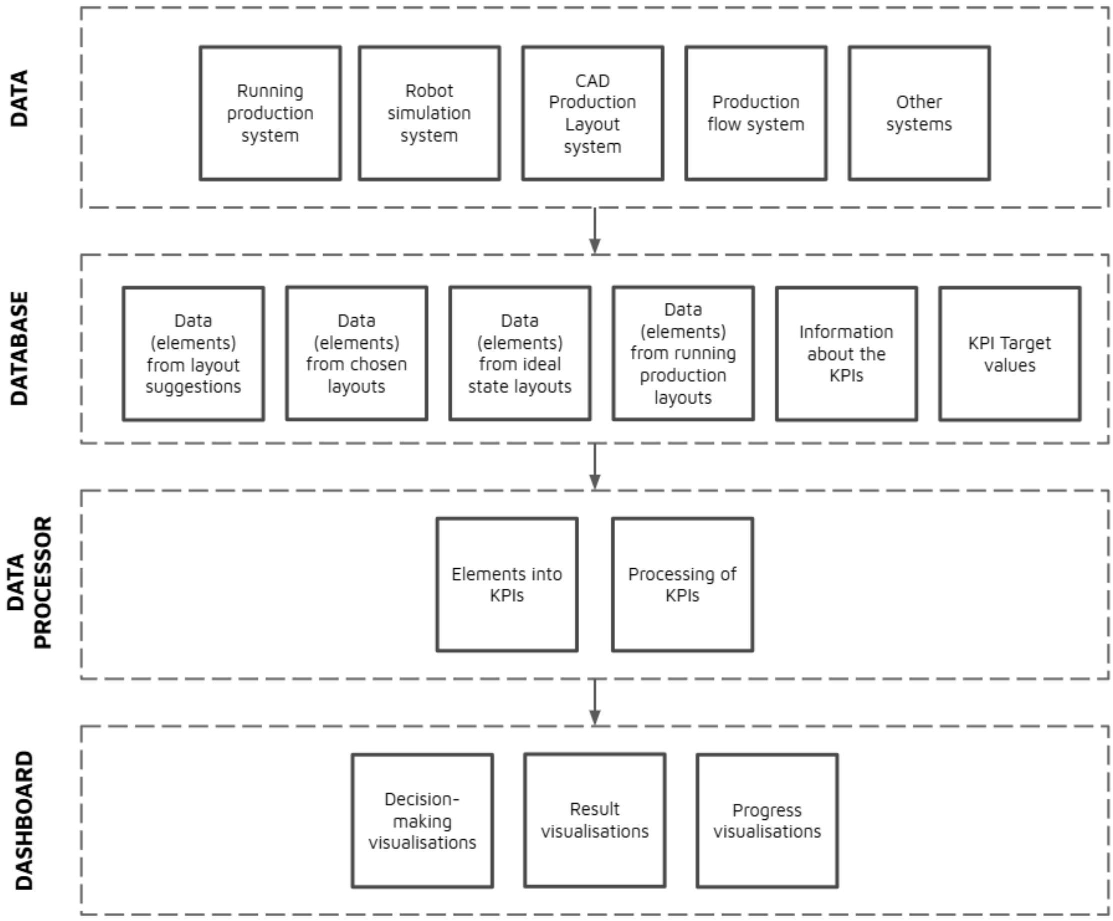


Figure 8.5: Process schedule of the IT-tool

The basic data (the elements) is produced from some kind of system, followed of being stored in the database. The database does not only contain elements, but also information about the KPIs and their target values. Further, the data is processed, thus creating elements into KPIs and making possible balancing evaluations.

Finally, the result is showed in different dashboards, where three main visualizations have been identified as appropriate: Decision-making visualizations, Result visualizations and Progress Visualizations. The key idea is to visualize the PMs and data in a manageable way on the dashboard in order to making it simple of taking strategic decisions and showing results, according to specified requirement list. Continuously, the dashboard makes it possible for the user to orient in decision-making, results and progress, including compartments with the ideal state and progress old projects. It should also be possible to track and visualize the performance over time, comparing different project in different phases.

9
Discussion

This chapter includes discussions about the Quality of Research, Findings, Sustainability aspects and Future implications.

9.1 Quality of Research

For this thesis, a systematic combining research approach was used in order to triangulate the problem and use both inductive and deductive approaches. The case was studies through qualitative research, including semi-structured interviews and observations.

Bryman et al. (2014) emphasize that quantitative research tends to use an deductive approach which focus on testing existing theories whereas qualitative research on the other hand tends to use an inductive approach which focus more on generating theories. In this case, the study aimed to have both a top-down as well as an bottom-up approach in order to provide suggestions on how Volvo Cars could improve their current situation. This, together with the knowledge that PMS' in early production development phases are quite unexplored, indicated that a qualitative approach was most appropriate for the task.

Quantitative and qualitative research can be combined into mixed research methods, which is very popular in business and management research (Bryman et al. 2014). The mixed methods strategy makes it possible to offset the weakness and gain the strengths of each method, and would continuously been a strong research option of conducting the study. Though, after the quite extensive qualitative study with 26 interviewees, all aspects necessary for answering the research questions was fulfilled. Therefor, it was chosen to put the remaining effort on investigate the for prerequisites an IT-tool and a new suggestions of the PMS. The alternative would instead have been to prepare and conduct a quantitative study, with the purpose to only to confirm already existing data from the interviews.

Regarding the top-down approach, the study was limited to interview employees from Top Management at department level Manufacturing Engineering, Quality and Operational Development, and Business Office. If the study would have included interviewees from an even higher organizational level, this would have given an different view on the importance of different performance objectives connected to BIW. Similarly, the choice of interviewees from the bottom-up approach, primarily

Engineers, was limited due to time constraints and mainly involved employees that had previous been involved in the design and revising of the current PMs. This might have affected the result to become biased, as aspects from employees that have been less involved in the process might have been missed. Further, the choice of not performing a horizontal study (between departments) might also have affected the results, and it should be emphasized that the issues discussed are issues that have been highlighted from BIW's point of view. Though, considering that this was part of the thesis' constraints, this is an expected consequence.

The frameworks and other solutions developed in this thesis have not been evaluated, mainly because of time constraints and the scope of the thesis. The authors thought of having workshops and/or performing a online survey to verify the results, but the time was unfortunately not enough. It is possible that the thesis could have evaluated the results if the scope of the thesis was smaller. According to Walker H. et al. (2013) it is important to go through the steps in the Plan-Do-Check-Act (PDCA) cycle when implementing and evaluating improvement work. In this thesis, in regards to developed models and solutions, the first two steps in the PCDA cycle have been passed. To validate the results, it would be beneficial to also go through the last two steps; check and act. Also, an iteration of the models could possible provide new insights to the problems that have been studied, to further develop the models.

9.2 Findings

The problem analysis of the study was concluded into three research questions, aiming to mapping the previous PMS and provide future suggestions. Below follows a critical discussion of key decisions and points that is important to highlight.

9.2.1 Research Question 1

How is Performance Measurement Systems during early production development phase defined and managed?

For mapping the current state of the PMS, the KPI lifecycle developed by Almström et al. (2017) was used, together with a present state analysis method inspired by Landström, Almström, Winroth, Andersson, Windmark, Shabazi, Wiktorsson, Kurdve, Zachrisson, Ericson Öberg & Myrelid (2016). The results was analyzed through a two-step analysis method, where they were problems and needs was defined.

For this thesis, it was decided to take a problem-oriented approach in order to identify problem areas and thereafter develop suitable solutions. The main reason to this approach depended on the fact that parallel work has been performed. At the same time as the thesis has been carried out, BIW has internally conducted an evaluation of the current measurements. This might accordingly have affected the results, and it should be highlighted that certain findings and suggestion of improvements might already have been carried out.

An interesting finding from the results is that the purposes for early production development phases differ, or has additional purposes, compared to the traditional view of PMs (where Controlling, Reporting and Improving are the basic categories). Continuously, it can be concluded that PMs in early production development phases needs to be managed and defined differently, compared to running production.

9.2.2 Research Question 2

How can Performance Measurement System during early production development phase be improved?

Several steps of analysis was used to reach a conclusion regarding the improved future state. Also, important to emphasize is the fact that developed frameworks from Research Question 3 helped to reach a conclusion for a new PM structure, missing KPI areas, the requirements and rough process for a an IT-tool, thus supporting the outcome for Research Question 2.

One aspect that is important to emphasize from the analysis is the lack of feedback-loops from other departments, such as running production. Since BIW is in the early production development phase, a lot of the data during the development process is insecure or based on estimations for part of the process, as earlier explained. Even towards the later phases of early production development, when finalizing the production layouts, there is some uncertainty in data. This raises the question whether it is possible that real and "true" data (for the PMs in early production development) is not available until the project is realized i.e. when the production is up and running? Considering that things don't always turn out as planned, it should be by high concern to the organisation whether the simulated numbers and ”educated guesses” matches with the real outcome. Consequently, it is very important for BIW to make sure that such a controlling function are performed, something that can be realized by implementing the IT solution and related functions.

9.2.3 Research Question 3

What should a framework look like that could help the transition between current to improved state?

According to Cambridge Dictionary is a framework a ”system of rules, ideas, or beliefs that is used to plan or decide something” (Cambridge 2019). Accordingly, there is a lot of room for interpretation considering what is a framework is and is not. In this thesis' case, the two models from section 8.3 and 8.4 is considered being developed ”frameworks”. Considering the aim of the thesis and the context of help in the ”transition” process between current and improved state, these two models fulfills these prerequisites.

Considering the ”generalisability” of the two frameworks, it should be possible to presume that the problems identified for BIW and Volvo Cars is not unique, but also applicable on other companies and industries. Considering the lack of information about ’enabling indicators’, a model for breakdown of strategies and objectives into KPIs as well as a model for connecting KPIs to Operational Excellence, Lean and Industry 4.0 should be suitable for many kinds of corporations, which have some kind of operational function for production development. This also refers to the IT solution which requirement list and process scheme have been developed with a problem development approach, and although it has been developed with inputs from the case study context, the tool is expected to be suitable for other similar companies.

9.3 Sustainability

In terms of sustainability the thesis mainly targets societal and ethical aspects. Though, when it comes to ecological sustainability, a more accurate PMS can help BIW to focus on higher strategic targets, such as sustainability, and continuously more easily work in right direction. Further, providing a ’better’ PMS creates a overall more sustainable environment, considering that time can be saved in the development process, due to easier data handling, tracking and decision making. The improved connection between BIW, production and product development and increased alignment with strategy will also help BIW to chose the right PMs.

9.4 Future implications

A topic that has been discussed in the analysis is the concept of trade-offs and possibility to weighting measurements and KPIs against each other, in order to make the decision-making process easier, faster and more based on current strategy. This can be helpful when BIW has to compare two or more production layout suggestions against each other, that all score high results but on different KPIs or PMs. To have a PMS that is connected to an IT-tool and a database that can provide dashboards with weighting functions of the KPIs, with respect to current strategies and objectives could perhaps make it easier to motivate certain decisions. Another dimension of weighting could be to have the IT-solution regard dimensions on the business market that normally is not taken into consideration, such as trends on the market or an upcoming shortage of parts or materials for certain equipment that can affect the profitability. But more research within this area is needed in before anything certain can be stated.

In order for the framework to be more applicable and generalized more departments from Volvo could be included in the study other then BIW, for example departments such as Tooling and Equipment, Geometry, the Paint shop as well as Supply Chain, see figure 4.1. A broader study might give an even better and more accurate system view of current PMS.

When it comes to BIW regarding Industry 4.0, as mentioned in section 6.5, many of the interviewees believe that more value can be gained from new technologies and the work towards I40. Much value, at least in terms of saving time, can probably be added through connecting the many different data systems and software's that produces PM data that currently exists at BIW. But there is no value in spending time and money on new technologies for the sake of just having new technology. In order to benefit from using technologies such as Big Data and Artificial Intelligence, BIW should probably put more effort on fixing the current problems that exists now, such as making the PM data gathering process smoother.

10
Conclusion

The purpose of this thesis was to "investigate and evaluate how Performance Measurements Systems are defined and managed during early production development phases in the automotive industry, in order to develop and provide an integrated framework to ensure alignment between the corporate manufacturing strategy, goals, objectives and Performance Measurements". In order to fulfill this aim, the problem was broken down into three research questions, summarized into current and future state. This chapter presents the thesis' reached conclusions regarding this.

10.1 Current state conclusions

Research Question 1, definition and management of current Performance Measurement system, resulted in three main outcomes: (1) mapping of current PMS, (2) definition of the purposes of PMs in early production development phases, and (3) identification of improvement areas. In conclusion, the results indicates that managing Performance Measurement in early production phases is quite different from managing PMs in running operation. This is especially apparent when it comes to the PM's purposes which deviates from the 'traditional' view of the role of PMs:

The thesis has shown that the PMS structure in a early production development phase has four main stakeholders with different corresponding PM purposes: Top Management which uses them mainly for guiding purposes, Program Managers which uses them for mainly controlling and reporting, and Managers and Engineers which them for the same reasons as program managers but also for decision-making and explaining purposes. The identified improvement areas connected to current state of the PMS are Communication, Alignment and Feedback, Education and knowledge of Lean, PMS structure, PM structure, and Data systems.

Consequently, in order to take advantage of having PMs in early production development phases, a PMS management which considers these topics needs to be taken into consideration.

10.2 Future state conclusions

The conclusions from current state regarding future management is closely related to the outcomes and conclusions drawn from Research Question 2; improvement of current Performance Measurement system, and Research Question 3; developing of frameworks. The outcomes from research question 3 can be considered as the most important subjects for fulfilling the thesis' purpose and aim and consists of:

- A model for connecting KPIs with Operational Excellence in early production development phases
- A model for KPI identification from high-level objectives and strategies

These two points are important for production development departments in order to align with higher-level targets and in order to take the right decisions in line with the company vision. The model for connecting the KPIs with Operation Excellence is useful for giving a better system view of how the KPIs are related to the organization's operational improvement journey, and how they are connected to lean practices (e.g. ideal state) and Industry 4.0, whereas the model for KPI identification is important for the revising phase, in order to make sure that chosen KPI's has a clear connection to manufacturing strategy.

The two models/frameworks is directly associated with the outcomes from research question 2 which consists of: (1) New PM Structure, (2) Missing KPI area, and (3) Suggestion of an IT solution. Point 1 and 2 refers to covering and defining a more 'complete' and comprehensive PM system, whereas point 3 refers to the development of an IT tool which is important for solving many of the current issues. Finally, the managing guidelines of the PMS is based on the SWOT- and TOWS-analysis and can be used to further develop and improve the PMS, specifically at BIW.

10.3 Final conclusions

Given that very little research has been performed in the area of Performance Measurement Systems in early production development phases, this thesis is expected to provide valuable insights on how PMs are defined and can be approach and managed in this context. Having PMs in place in early production development phases has proven being a powerful tool for driving certain behaviors and support in decision making processes. This also means that there exists big potential benefits for an organisation of having a PMS in place during production development, although this also indicates how important it is to choose the right kind of PMs - in order to drive the organisation in the right direction it is very important that they are aligned and derived from strategy.

11

Recommendations

In this chapter the final recommendations are given, both regarding future steps for Volvo Cars, as well as future research areas.

11.1 Recommendations of future work

For Volvo Cars and BIW, the following recommendations can be given in order to improve their current situation:

1. Implement and evaluate suggested arrangements discussed in the future state chapter:
   - Implement the thinking from the ”Operational Excellence - KPI connection model”, to make sure that employees understands the KPIs’ purposes
   - Implement new suggested PM structure
   - Evaluate given KPI and Measurable suggestions, use the developed ”KPI Identification model” to analyze other important KPI areas
   - Create a pilot for the IT solution, according to suggested requirements list and process-map
2. Implement other suggested guidelines from TOWS, regarding strengthening internal capabilities:
   - Better and more communication from top management down to engineering level
   - Better and more communication between the plant and ME
   - Allow more time for PMS education
   - Investigate identified PM conflicts and align
   - Standardise data collection methods
   - Set targets for all KPIs
3. Future investigations:
   - Look into possible PM alignment with other departments, especially P&Q.
   - Look into possible ”People Development”-related PMs

11.2 Future research

Regarding future research, the following areas are suggested to be further investigated:

- Test and evaluation of suggested frameworks and solutions
- More research within possible applications and implications regarding PMs in early production development phases
- Possibility of ”weightening” KPIs against each others

Bibliography

Allio, M. K. (2012), 'Strategic dashboards: designing and deploying them to improve implementation', *Strategy & Leadership* **40**(5), 24–31.

Almström, P., Andersson, C., Ericson Öberg, A., Hammersberg, P., Kurdve, M., Landström, A., Shahbazi, S., Wiktorsson, M., Windmark, C., Winroth, M. & Zachrisson, M. (2017), *SuREBPMS: Sustainable and resource efficient business performance measurement systems - The handbook*, Mölndal: Billes Tryckeri.

Anderson, J. C., Cleveland, G. & Schroeder, R. G. (1989), 'Operations strategy: a literature review', *Journal of operations management* **8**(2), 133–158.

Ante, G., Facchini, F., Mossa, G. & Digiesi, S. (2018), 'Developing a key performance indicators tree for lean and smart production systems', *IFAC-PapersOnLine* **51**, 13–18.

Bazire, M. & Brézillon, P. (2005), 'Understanding context before using it', *Context* (3554), 29–40.

Bititci, U., Carrie, A. & McDevitt, L. (1997), 'Integrated performance measurement systems: An audit and development guide', *The TQM Magazine* (9), 46–53.

Bryman, A. & Bell, E. (2011), *Business research methods*, Oxford: Oxford University Press, ISBN: 9780199583409.

Bryman, A., Bell, E., Hirschsohn, P., Dos Santos, A., Du Toit, J., Masenge, A., Van Aardt, I. & Wagner, C. (2014), *Research Methodology: Business and Management Contexts*, Cape Town: Oxford University Press Southern Africa.

Cambridge (2019), 'Cambridge dictionary: 'framework', URL: https://dictionary.cambridge.org/dictionary/english/framework (visited on 29/05/19)'.

Dubois, A. & Gadde, L. (2007), 'Systematic combining: an abductive approach to case research', *Journal of Business Research* **55**(7), 553–560.

Eckerson, W. W. (2009), 'Performance management strategies', *Business Intelligence Journal* **14**(1), 24–27.

Franceschini, F., Galetto, M. & Maisano, D. (2007), *Management by measurement - Designing Key Indicators and Performance Measurement Systems*, New York: Springer, ISBN: 9783540732129.

Frolick, M. & Ariyachandra, T. (2006), 'Business performance management: One truth', *ISM-journal.com* **Winter**.

Fülscher, J. & Powell, S. (1999), 'Anatomy of a process mapping workshop', *Business Process Management Journal* **5**(3), 208–238.

Gilchrist, A. (2016), *Industry 4.0. [electronic resource] : The Industrial Internet of Things*, Apress.

Graziano, A. M. & Raulin, M. L. (2014), *Research methods. [electronic resource] : a process of inquiry*, Pearson Education, ISBN: 1292053305.

Gupta, P. (2006), *Six Sigma Business Scorecard - creating a comprehensive corporate performance measurement system*, Vol. 2, New York: McGraw-Hill Professional, ISBN: 9780071479431.

Holweg, M., Davies, J., Meyer, A. d., Lawson, B. & Schmenner, R. W. (2018), *Process Theory : The Principles of Operations Management*, Vol. 1, Oxford: OUP, ISBN: 9780199641055.

ISO/DIS:22400-1 (2013), '2013(e): Manufacturing operations management - key performance indicators', *Draft International Standard* .

Kaplan, R. S. & Norton, D. P. (1992), 'The balanced scorecard - measures that drive performance.', *Harvard Business Review* (1), 71.

Karl, U. (2003), 'KJ diagrams, URL: http://opim.wharton.upenn.edu/ ulrich/documents /ulrich-kjdiagrams.pdf (visited on 20/03/19)'.

Keizer, J. & Kempen, P. M. (2006), *Business research projects [electronic resource] : a solution-oriented approach*, Amsterdam ; Boston : Butterworth-Heinemann, ISBN: 0750665734.

Krafcik, J. (1988), 'Triumph of the lean production system', *MIT Sloan Management Review* **30**(1), 41–52.

Kutnick, D. & Allen, B. (2002), *Building Operational Excellence. [electronic resource]: IT People and Process Best Practices*, IT Best Practices Series, Boston: Addison Wesley Professional, ISBN: 9780201767377.

Landström, A. (2018), *A present state analysis method for performance measurement systems*, Licentiate thesis / Department of Technology Management and Economics, Chalmers University of Technology: 2018:105, Gothenburg: Chalmers University of Technology.

Landström, A., Almström, P. & Winroth, M. (2016), *Performance indicators at different organisational levels in manufacturing companies*, Edinburgh: Presented at the 10th conference of the Performance Measurement Association.

Landström, A., Almström, P., Winroth, M., Andersson, C., Windmark, C., Shabazi, S., Wiktorsson, M., Kurdve, M., Zachrisson, M., Ericson Öberg, A. & Myrelid, A. (2016), *Present state analysis of business performance measurement systems* *in large manufacturing companies*, Lund: Presented at the Swedish Production Symposium.

Laugen, B. T., Acur, N., Boer, H. & Frick, J. (2005), 'Best manufacturing practices: What do the best-performing companies do?', *International Journal of Operations Production Management* (2), 131.

Liker, J. K. (2004), *The Toyota way [electronic resource] : 14 management principles from the world's greatest manufacturer*, IT Best Practices Series, New York: McGraw Hill, ISBN: 0071392319.

Marchand, M. & Raymond, L. (2018), 'Characterising performance measurement systems as used in smes: a field study', *Benchmarking: An International Journal* **25**(8), 3253 – 3275.

Maskell, B. (1991), 'Performance measurement for world class manufacturing: A model for american companies', *Productivity Press: Portland, OR.* .

McKinsey&Company (2014), 'Next frontiers for lean, URL: https://www.mckinsey.com/business-functions/operations/our-insights/next-frontiers-for-lean (visited on 14/04/19)'.

McKinsey&Company (2019), 'The digital difference in measuring production performance, URL: https://www.mckinsey.com/business-functions/operations/our-insights/the-digital-difference-in-measuring-production-performance (visited on 03/05/19)'.

Mercadal, T. (2019), 'Value chain.', *Salem Press Encyclopedia* .

Neely, A., Richards, H., Mills, J., Platts, K. & Bourne, M. (1997), 'Designing performance measures: a structured approach', *International Journal of Operations Production Management* (11-12), 1131.

Nolan, D. & Anderson, E. (2015), 'What is operational excellence (OE)?', *Applied Operational Excellence for the Oil, Gas, and Process Industries, Gulf Professional Publishing,* pp. 1–37.

Power, J. (2018), 'Press release new-vehicle initial quality improves again, j.d. power finds, URL: https://www.jdpower.com/business/press-releases/2018-us-initial-quality-study (visited on 02/03/19)'.

Schuh, G., Anderl, R., Gausemeier, J., ten Hompel, M. & Wahlster, W. (2017), 'Industrie 4.0 maturity index', *Managing the Digital Transformation of Companies* .

Scupin, R. (1997), 'The KJ method: A technique for analyzing data derived from japanese ethnology.', *Human Organization* **56**(2), 233.

Sirkin, H., Hemerling, J. & Bhattacharya, A. (2008), *Competing with everyone from everywhere for everything*, Vol. 36, London: Headline Book Publishing - Strategy and Leadership, ISBN: 9780071086950.

Skinner, W. (1969), 'Manufacturing- missing link in corporate strategy', *Harvard Business Review* **May-June**.

Slack, N. & Lewis, M. (2010), *Operations Strategy*, Harlow: Pearson Education, ISBN: 9781292162492.

Sreejesh, S., Mohapatra, S. & Anusree, M. R. (2014), *Business Research Methods [electronic resource] : An Applied Orientation*, Springer International Publishing, ISBN: 9783319005393.

Srimai, S., Radford, J. & Wright, C. (2011), 'Evolutionary paths of performance measurement: an overview of its recent development', *International Journal of Productivity and Performance Management* **60**(7), 662–687.

Stewart, J. (2012), *The Toyota Kaizen continuum. [electronic resource] : a practical guide to implementing lean*, Boca Raton, FL: CRC Press, ISBN: 9781439846049.

Ulrich, K. T. & Eppinger, S. D. (2012), *Product design and development*, New York: McGraw-Hill/Irwin, ISBN: 9780071086950.

Walker H., F., Elshennawy Ahmad, K., Gupta Bhisham, C. & McShane Vaughn, M. (2013), *Certified Quality Inspector Handbook*, Vol. 2, American Society for Quality (ASQ), ISBN: 9781621980735.

Weihrich, H. (1982), 'The TOWS matrix - a tool for situational analysis', *Long Range Planning* **15**(2), 54 – 66.

Wheelwright, S. & Hayes, R. (1985), 'Competing through manufacturing', *Harvard Business Review* **63**(1), 99 – 109.

Wiktorsson, M., Andersson, C. & Turunen, V. (2018), 'Leading towards high-performance manufacturing – enabling indicators in early R&D phases ensuring future KPI outcome', *Procedia Manufacturing* **25**(Proceedings of the 8th Swedish Production Symposium (SPS 2018)), 223 – 230.

Yin, R. K. (1994), *Case study research : design and methods*, Vol. 5, London: SAGE, ISBN: 0803956630.

Zeller, V., Hocken, C. & Stich, V. (2018), 'Acatech industrie 4.0 maturity index-a multidimensional maturity model', pp. 105–113.

A

Appendix - Interview questions

Interview Template
Date: 2019-XX-XX Time: XX:XX to XX:XX

Note! Abbreviations: **TM**: questions asked to Top Management at M&L and ME **TM Plant**: questions asked to Top Management at Plant Torslanda **TM BIW**: questions asked to Top Management at BIW **M**: questions asked to Managers at BIW **PM**: questions asked to Program Managers at BIW **E**: questions asked to Engineers (including Operations Development Engineers, System Manufacturing Engineers, Process Engineers and Simulation Engineers) at BIW

Name:
Title:
Department:

Information to the interviewee:

Hi! My name is XX an I am doing my master thesis here at Volvo Cars, at BIW together with YY. The subject for our master thesis is KPIs, alignment of strategy and ideal state concepts. This interview is to help us understand how work is done at Volvo Cars, BIW, and for our master thesis work. This interview is planned to take approximately 60 minutes and it is divided into six parts: Background, Strategy and objectives, KPIs, PMS, Industry 4.0 and General questions. You can at any time abort this interview and you don't have to answer questions that you don't feel like answering.

Would you like to be anonymous? (YES/NO)

Is it ok if we record the interview? (So that I don't miss out anything, when writing notes) (YES/NO)

Please help yourself with some fika!

A. Background (TM, TM Plant, TM BIW, M, PM, E)

1. What is your background?

2. How would you describe your role and position at Volvo Cars?

B. Strategy and objectives (TM, TM Plant, TM BIW, M)

1. Department objectives
   - What are the current main objectives for your department and which one/ones are the most important and why is that so?
   - What are the future main objectives for your department and which one/ones are the most important and why is it so?
   - How and what do you measure to reach the objectives mentioned above?
2. Department strategies
   - Which are the most important strategies that you follow?
   - How well do you think you/your team follow the strategies?
3. Lean Transformation
   - What is the purpose of ideal state?
   - What are current KPIs used for?

C. KPIs (in BIW) (TM BIW, M, PM, E)

1. Purpose
   - What KPIs/Measurables are your department currently using and what are they for?
   - A way of grouping the KPIs in regards to what kind of function they have: improvement, report or control. These KPIs you have mentioned, which function would you say they have of these three categories?
   - According to you, what should be measured and why?
2. Weightening of current KPIs
   - Which one/ones are the most important and why?
   - How do you think the results from the KPIs should be used in the company?

D. Performance Measurement System (M, E)

1. Design & Revise
   - Who is responsible for designing the KPIs and how is it done today?
   - Who sets the target value for each KPI?
   - How should the design/revise process of KPIs be improved?
2. Implement
   - Who is responsible for the implementation of KPIs and how does it look like today?
   - How should the implementation process of KPIs be improved?
3. Usage (overall)
   - During the different phases of the car program, which KPIs are used and when?
   - What has been bad with the usage of the KPIs? What has been good?

- Who measures the KPIs/Measurables?

4. Data collection
   - Who is responsible for collecting the KPI/Measurables data and how do you collect data in order to calculate the KPIs/Measurables?
   - Which systems are you using today to collect the data and how is it stored?
   - How is the system performing in respect to collecting the data? (easy/difficulty?)
   - How and when are the collected data sent after it is collected? To who?
   - What would you like to change in respect to collecting data?

5. Reporting
   - Where, how and when are the KPIs reported? (in which system)
   - Who is using the reported KPI results? How are they analyzed?

6. Other PMS-related
   - What is good with the current system (PMS) that you have today?
   - What could be improved?

D. Industry 4.0 (TM, TM Plant, TM BIW, M, PM, E)

1. What are your thoughts on new concepts and technology such as Industry 4.0, Smart Factory, Big Data, Digitalization, Internet of things, Connected systems and AI?

2. Which of these mentioned concepts and technologies are Volvo currently using?

3. What is the current strategy regarding these concepts and technologies?

E. General question (TM, TM Plant, TM BIW, M, PM, E)

What would you like to add?

Would it be OK if I contact you again if I have more questions?

Of the topics we have touched, is it OK if we use this information in our master thesis work, such as in the report?

Thank you so very much for your time and your answers!

B

Appendix - Problems & Needs Analysis

Below follows an explanation of the following four pages within this chapter:

Abbreviations:

TM: Top Management at M&L and ME
TM Plant: Top Management at Plant Torslanda
TM BIW: Top Management at BIW
M: Managers at BIW
PM: Program Managers at BIW
E: Engineers (including Operations Development Engineers, System Manufacturing Engineers, Process Engineers and Simulation Engineers) at BIW

Explanation of criticality of need:

Level of criticality = ProblemDepths * NeedLevel

ProblemDepths: Number of stakeholder groups that have mentioned the problem (the degree of prolem depths within the organization);
Score between 1-6

NeedLevel: Score related to if implemented today (Yes/Partly/No);
Yes = 0, Partly = 2, No = 3

Explanation of colour indices:

Deep red: A need with a criticality index >=9
Light red: A need with a criticality index 5-8

WHO	WHAT		NEED	Implemented?	"Need level"	Examples	Level of criticallit
OTHER KPIs							**Level of criticallit**
WHO	WHAT		NEED	Implemented?	"Need level"	Examples	
TM BIW, E	People Development		KPI related to people progress: - On Team level - On Personal level	No	3	*"We are missing som kind of measurement system for people development, like a competence matrice"*	6
'LEAN" KPIs							
PURPOSE BODY KPIs							
WHO	WHAT		NEED	Implemented?	"Need level"	Examples	
TM ME	Possible to chose what to use them for		-	-	-	*"It is possible to choose what to use the Body KPIs for"*	
E	Be possible to use for everybody		Engineers, managers as well as top management should draw benefits from the KPIs	Partly	2	*"The KPIs must work on every level, from us and up to top management"*	2
TM ME	Breakdown of KPIs	Result KPI: the final result (mfc/car) Process KPI: the processes that should acheive the result	More clear division between result and process KPIs	No	3	*"There are two types of KPIs, in my definition. Are we talking about result or the processes that should achieve the results"*	3
TM ME, M, E	For improving aims		Implementation of a proper KPI usage into the organisation: *a tool which can help steer the production planning process towards a better state*	Partly	2		6
TM ME,		To drive the right thinking and behavior			2	*"They KPIs are there to drive. Drive the right behavior and thinking"*	6
M		Alignment of thinking - to create better processes			2	*"To have a ready-to-use-solution, to align how people thinks. To be used with Body fundamentals and lean KPIs"*	2
TM ME		Not to judge	The KPIs should not be used to judge	Partly	2	*"They KPIs are not there there to judge"*	2
M, E	For reporting aims	To report to top management	**Overall reporting function**			*"The way we do now is mainly reporting"*	
E		To report manufacturing cost/car	Reporting function for manufacturing cost/car	Yes	0	*"Manufacturing cost per car is used to report"*	0
M		To report progress in relation to PP20	Reporting function in relation to PP20 targets	No	3	*"I think it is a measurable were you can see the progress, how to improve, towards the PP20"*	3
TM BIW, M, E	For controlling aims	To making sure that progress is going in right direction	**Overall feedback function**			*"The KPIs as we have today are very good because they steer us in a good direction"*	
TM BIW		To follow up throughout a single project	Showing project progress through the phases, for a single project (showing filled in KPIs)	No	3	*"I think in a later phase the KPIS are used more to follow up"*	3
TM BIW, M, E		To follow up following performance of implemented solutions	Showing current performance from running production of the KPIs	No	3	*"I think it is important that we can use and connect the KPI and PMS to running production, to connect more to the running production, we are not learning enough"*	9
M, E		To follow up progress between current and previous projects	Showing current performance in relation to previous performance	No	3	*"Honestly, we don't know [today] if we are getting better or not"*	6
M		To reach our objectives	KPIs aligned with overall objectives: - PP20 - Other department objectives	Partly	2	*"We use the ideal plant KPIs to measure and reach the objectives"*	2
M, E	For comparement aims	To compare	**Overall comparement/visualisation function**			*"It should be easy to compare, visualise, and present the data of the KPIs"*	
TM BIW		To compare in relation to target values	Showing performance in relation to target values (PP20 for instance)	No	3	*"To become Best-in-class is we are measuring and comparing through the PP20 targets"*	3
M, E		To compare between time	Showing performance during time	No	3	*"For new projects, I want to be able to look on past work and see if I'm getting better or not "*	6
M, E		To compare between different projects	Showing performance between different projects	No	3	*"To be able to compare concepts and solutions"*	6
M		To compare planning phase with running phase	Showing performance calculated during planning phase with performance during running phase	No	3	*"There is a lot of data in running production. You can't always compare data in planning phase with running phase, because of simulation and estimations"*	3
M		To compare between the different plants (OBS: Also noted that this can be dangerous due to different measurement methods between countries)	Showing performance between different plants	No	3	*"The different plants measure in different ways and the numbers get "hidden" by how they measure"*	3
M		To compare between different processes (OBS: Also noted that this can be difficult as the rocesses looks so different)	Showing performance between different processes	No	3	*"They can be used to compare the different processes"*	3
E		To compare between different car manufacturers	Showing performance between different Car manufacturers	No	3	*"It is not easy today to compare our KPIs with other car manufacturing, because there is no standard"*	3
TM BIW, M, E	For decision-making purposes	To help taking the right decisions when comparing layouts	**Overall decision-making function**			*"To help and support us in the decision making, guiding through which concept to chose"*	
TM BIW, M, E		To compare layout suggestions aginst each other	Decision-making function between layout suggestion and layout suggestion	No	3	*"To be able to compare different concepts/solutions/layouts"*	9
TM BIW, M, E		To compare between new layouts against current layouts	Decision-making function between new layouts against current layouts	No	3	*"Compare between current existing layout (reference) and new layouts"*	9
TM BIW, M, E		To compare between new layouts against ideal plan layouts	Decision-making function between new layouts against ideal plant layouts	No	3	*"We need to benchmark future layouts, Ideal plant, not current"*	9
	For explaining aims		**Explanations**				
TM BIW, M, E		To motivate why certain decisions are taken	Data to explain why a certain decision are taken	Partly	2	*"To explain why we have chosen a certain layout. We have had difficulties to motivate different choices historically."*	6
GOOD THINGS BODY KPIs							
WHO	WHAT					Examples	
TM ME, TM BIW, M, E	Today's KPIs are pretty good					*"The KPIs as we have today are very good because they steer us in a good direction. It is good to have them in the early phase, we get better and better. Can see through the phases. The evolution is very good captured with the KPIs"*	
TM ME, TM BIW, M, E	The KPIs today are better and easier to understand compared to before					*"Better approach to the KPIs now, was very challenging in the beginning but with explanations people understood more why"*	
M, E	Better focus on the right things *- before more focus on investment (making things as small and cheap as possible)* *- now more focus on long-term targets*					*"It is better now. Before we used to focus only on investment, choosing the cheapest option"*	
PROBLEMS BODY KPIs							
WHO	WHAT		NEED	Implemented?	"Need level"	Examples	
DESIGN AND REVISE							
	Lack of proper definitions		**More clear definitions of the KPIs**				
E		Everything is called KPIs	Clarification of what a KPI is (and what is not)	Partly	2	*"Everything that we measure is refered to as a KPI"*	2
E		No calculation examples	Calculation examples	Yes	0	*"It is difficult, to know how to calculate the KPIs"*	0
E		Of what KPI that is connected to what	Clarification of the KPIs connection to each others	No	3	*"We would like to have a order where the most important is highest, and what is connected to what"*	3
TM BIW, M, E		Of KPI: *Manufacturing cost per car*	Breaking down manufacturing cost per car more into more parts	No	3	*"Breaking down manufacturing cost/car into which parts that affects it would be a good idea"*	9
E		Of KPI: *Manpower flexibility* (with 100/50 we suboptimize)	Looking over the definition of Manpower flexibility so it is not suboptimizing	No	3	*"The manpower flexibility is not perfect now, having it 100/50 gets us to suboptimize"*	3
E		Of KPI: *Squaremeter cost*	More clearer state how to calculate Sqm cost	Partly	2	*"We don't understand sqm cost. Get a better definition page, with descriptions and explanations"*	2
E		Of KPI: *Investment*	Looking over the definition of Investment: - So it takes into account changes over time - So it is clear what is type bounded or not	No	3	*"Difficult to check investment costs: changing costs after project for instance (as the product changes), should we take that into account?" "Difficult to find the right kind of type bounded (70/30 division or similar, division between products)"*	3
	Not possible to affect the end-result		**KPIs that are practically possible to affect**				

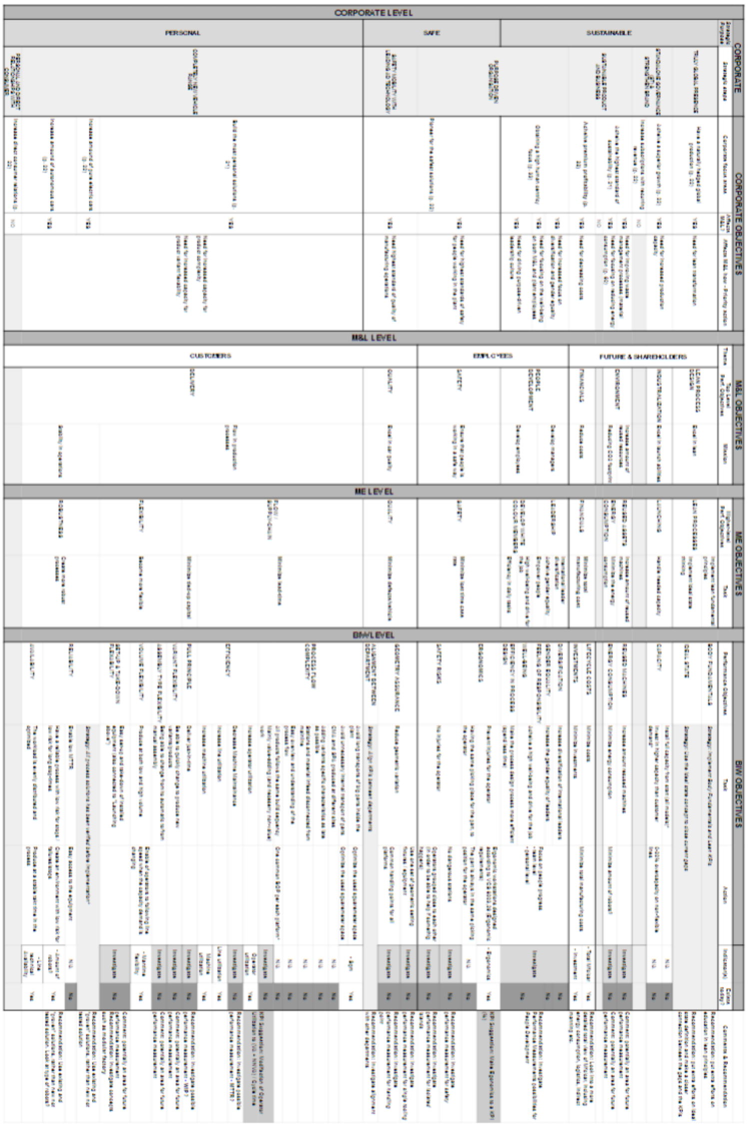
E		Of KPI: Investment	Looking over if Investment is a suitable KPI, considering so that the end-result is possible to affect	No	3	*"We have really high standards in Torslanda, we don't have this in China, this gives different investments that I can't really control over"*	3
	Lack of relevant comparisions		**Better targets for the KPIs**				
TM BIW, M, E		Difficulty to set targets for all KPIs	Set targets for all KPIs	Partly	2	*"If not measured against any targets they are quite useless"*	6
			"General" targets for utalization KPIs, product/project dependent targets on others	Partly	2	*"To set reasonable targets are also important. Today, with how we work, some targets that we have is hard to reach (the targets probably comes from the a checklist, an old list that shows contradicting things with how we work now)"*	6
			Routines on how to set product/project dependent target values	No	3	*"We are not really used to set this target ourselves, it is an area of improvement. We don't really know the targets yet, we need to revise this. We need to see which what we can reach, benchmark"*	9
M		Difficult to compare "apple with apple" between the KPI results	Finding relevant ratio which shows fair comparisions (e. g kvm/JPH)	No	3	*"We don't measure apple with apple today"* *"I miss a relation between the different KPIs"*	3
M, E		Relevant targets of the KPIs	Relevant and acheivable targets	Partly	2	*"We are struggnling to compare the KPIs with something"* *"95% utalization is not even good to reach"*	4
	Prioritization issues		**State clear prioritization list of the KPIs**				
M, E		Difficult to know which KPI to focus on	Prioritization list/weightening of the KPIs	No	3	*"We would like to have a order where the most important is highest, and what is connected to what"*	6
	Greenfield and brownfield		**Relevance for both greenfield and brownfield projects**				
E			Should work both for greenfield and brownfield project applications	Partly	2	*"It needs to work for both greenfield and brownfield project, I am not sure if that is the case today"*	2
MISSING KPIs/Ms							
	Missing human centric indicators		**More human-centric KPIs**				
E		How good the line is in relation to the operators	Including more "human-centric" rKPIs	No	3	*"I miss KPIs that shows how good the line will be in relation to the operators (eg. ergonomics risk/line). So we can press that we need more investments."*	3
			Including more Safety related KPIs	No	3		3
	Missing Quality indicator	Quality is not measured today as a KPI	**Including Quality KPIs**				
E		Of process robustness	Including a KPI for Distruption Sensibility	No	3	*"We don't have a good quality measurement, not how robust the process is"*	3
M, E		Of geometrical deviations	Including a KPI for Geometry Assurance / Fitting	No	3	*"Our main [quality] goal is probably fitting. [...] We miss a KPI for quality today"*	6
	Missing Measurables		**Adding missing measurables**				
E		Man-time (in HH:MM) is part of running cost but only showed as percentage today	Including actual man time / car in some of the cost-related KPIs	No	3	*"We mesure today, man time, but just in percentage. It is not one of Ideal plant KPIs. Man time is part of running cost. How much hours, man hours, is used per car is a classic reporting KPI"*	3
E		Number of parts mounted ouside the plant	Including a measurable that shows number of parts assembled outside the plant	No	3	*"How many parts or assemblies that are not done today in the Body Shop (For example doors made in Olofström is transported to Torslanda and Gent)"*	3
M		Complexity of the product	Including a measurable that shows the complexity of a product	No	3	*"To measure the process designs, measure how complex a product is. Product design affects the cost and process a lot. A complex product design drives the cost, process design etc"*	3
	No diversification of KPIs		**Diversify the KPIs**				
M, E		Not having different KPIs for different units	Diversify the KPIs for different parts of BIW (Product, Process, SA...)	Partly	2	*"The different departments (within BIW) should have different KPIs, we (Product/Plant/Process) about our focus area, the other departments about how good their focus area are."*	4
IMPLEMENTATION							
	Lack of a PMS		**Implementation of a PMS**				
TM BIW		No system view of the KPIs	Implementation of system viewed KPI usage	No	3	*"We don't have a PM System today to be honest"*	3
TM BIW		Not working KPI driven	Implementation of a more KPI driven work	No	3	*"Today we don't work KPI driven"*	3
	Lack of understanding		**Better communication**				
M, E		Of the purpose of the KPIs	Better communication of the purpose of the KPIs	No	3	*"It is new for us to have the Ideal plant thinking, we would want to have something more clear, that you can touch."*	6
M, E		Of how to use the KPIs	Better communication on how to use the KPIs	Partly	2	*"I want clear decisions on what to do, how to do it, it is not clear"*	4
M, E		Of KPI: *Squaremeters*	Better communication of why sqm is important	No	3	*"I don't understand squaremeter at all, leads to worse processes"* *"I know that the square meter is not so important when we validate the process. But what we see in every project is that we discuss the square meter much. Then perhaps we have missed out on others "* *"It is hard to make changes based on lean kpi, square meter is not working together with the other lean KPIs I would say"*	6
E		Of the usage of the KPIs	Better communication of how to use the KPIs	Partly	2	*"Honestly, I have difficulty understanding what the purpose of the KPIs are, and how to use them"*	2
E		The implementation of the KPIs have been too quick	Have the PMS system definition ready before implementation	Partly	2	*"I would like to have have all the definitions ready, THEN we can implement, would be much easier"*	2
	Lack of time for education		**More time for KPI education**				
E		Not enough time given for implementation and education purposes	More time for education and implementation (isolated hours)	No	3	*"We need to sit isolated and try and test, not only for a few hours. We would reach much further then."*	3
USAGE							
	Lack of centralisation		**Centralisation of KPI storage**				
TM BIW, M, E		No system or database to store the KPI data in	A database for centralisation of the KPI data	No	3	*"We often get a target: next project should be 10% better but we have no place where previous results are stored. Does the lines get better or not? We don't know"*	6
E		Not knowing which KPIs that are up-to date	Better communication of where up-to date KPIs are possible to find / An easy place to always find up-to date KPI information	No	3	*"I'm having trouble knowing where to find information about the KPIs"*	3
	Lack of KPI alignment		**Better alignment**				
TM BIW		With Ideal Industrial Position	Alignment with Ideal Industrial Position KPIs	No	3	*"Our KPIs should support Ideal Industrial Position, they need to start measuring. They need to align which KPIs to use and how to measure them"*	3
M, E		With overal strategies	Alignment with Automation and Technical strategies	Partly	2	*"Important with connection to corporate strategy and objectives, alignment"*	4
M, E		With Body Fundamentals	Alignment with Body Fundamentals	No	3	*"Maybe some Body fundamentals is supporting Body KPIs. We don't have that connection now"*	6
TM ME, TM BIW, M, E		With Production	Alignment of running production KPIs and objectives	No	3	*"We don't follow up the real running process/production"*	12
TM ME, M		With P&Q	Alignment with Product KPIs and objectives	No	3	*"In th future we need to align and synchronise the KPIs with P&Q and Production"*	6
M		With the KPI usage	Alignment of the overall usage of the KPIs	Partly	2	*"Honestly, I have difficulty understanding what the purpose of the KPIs are, and how to use them"*	2
E		With ISO Standard	Alignment with ISO standard	No	3	*"Interesting to look into ISO standard for KPIs"*	3
TM BIW, M		With other departments (contradicting KPIs for instance)	Alignment with the other departments (logistics, maintainance, stamping) - Have some KPIs in common	No	3	*"The 3 KPIs on top should be the same for all departments - is it?"* *"We don't know what kind of KPIs the other units has"*	6
	Conflicts/Contradictions between objectives		**Solve/balance conflicts between KPIs and other**				

TM BIW, M, E, PM		Handling of conflicts	Overall balancing function	No	3	*"There is a conflict between utalization (KPI) and quality (objective)"*	12
E		Utalization (KPIs) with Quality (objective)	Balancing utalization KPIs with quality objectives (adjustment aspects)	No	3	*"Higher utalization indicates less time for quality supervision"*	3
E		Investments (KPI) with Ergonomics (M)	Balance investment KPI with Ergonomics M	No	3	*"Investment cost is e.g dependent how good we do it for the operators, e.g ergonomic requierements, we have really high standards in Torslanda, we don't have this in China, this gives different investments that I can't really control over"*	3
M		KPIs against Geometry	Add KPI that focus on geometry assurance	No	3	*"We have KPIs today that takes away focus on geometry"*	3
M		EBIT (objective) with strategies	Evaluate if current strategies contradicts cost KPIs	No	3	*"Going towards more manual solutions, this punishes EBIT"*	3
PM		Manufacturing cost per car with strategies		No	3	*"If we focus to much on mfc/car, strategy will suffer"*	3
M		Compactness with availability	Evaluate compactness (obejctive) with availability (objective)	No	3	*"Our senior vice president states that compactness is a driver for performance. But too compact processes can create a lot of unavailability at breakdowns. Certain trigger point, where availability goes down and other factors goes down."*	3
	"Hidden" facts issues						
E		Some adjustments are not done in A-factory but in C-factory	Method for visualize tasks that is not performed in A-factory	No	3	*"There will be "hidden numbers", as adjustments are done in e.g C-factory, when mounted in A-factory"*	3
E		The KPIs can't show the content of the processes	More content details of the processes when comparing the KPI results	No	3	*"We try to compare processes, but there is always differences. The KPIs don't always show the difference. The content of the processes that you compare does is not shown in KPIs"*	3
	Globalisation issues		**Usability on global level of the KPIs**				
M, E		Pre-requisites differ between plants	The KPIs should be applicable on a global level (all plants)	Partly	2	*"In China they have a much bigger spread of quality issues, due to manual work [....] there is a big difference between Europe and China"*	4
			Different KPI targets for different plants	No	3	*"We need to be able to compare between different plants and functions etc. That will be a challenge"*	6
E		Taking into account the different salaries between countries	Taking salary level into account for the KPIs	No	3	*"The salery between countries differ, that causes problems"*	3
	Time-consumption		**Minimize time consumption of KPI usage**				
E		Takes a lot of time to understand how to report the KPIs	Define a clear PMS, and communicate out how to use it	Partly	2	*"It takes a lot of time to understand how to report"*	2
TM BIW		Takes a long time to calculate all KPIs	An easier way to calculate the KPI values	No	3	*"... to calculate other KPIs are time consuming"*	3
	Lack of responsible person						
M		We don't have anyone specific that is responsible today	Select someone as a super-user that is trained and responsible for the PMS	No	3	*"We need a super-user that is trained and resposible"*	3
	No feedback						
E		Of if the KPI result is good or bad	Overall feedback method	No	3	*""Where does the data end up after it is used? PSR? Is that good or bad? It is not very clearly. How does the feedback happen after the data is processed"*	3
DATA COLLECTION							
	Lack of proper measurement methods		**Better measurement methods for the KPIs**				
E		How to collect data in relation to time (average value?)	Instructions on how to collect data for running production in relation to time (using the average value, a snapshot?)	Partly	2	*"I don't know if we collect the numbers in a correct way, we use the average number, is that the right way to do it?"*	2
E		Difficult to estimate correct costs (to relate towards given investments)	A clearer way to calculate "real" needed investments	No	3	*"In regards to cost it must always be estimated higher then it will be, or else we will not afford the investment."* *"We need a list of the 10 things that costs the most"*	3
E		Of KPI: *Investment* - how to think about changing costs during the time of the project	Define from which phases the data should be: - Collected - Revised	No	3	*"Difficult to check investment costs: changing costs after project for instance (as the product changes), should we take that into account?"*	3
M, E		Of KPI: *Investment* - how to divide between type bounded or non-type bounded	Clear instructions on how to diverse between bounded and type-bounded invetment	No	3	*"When it comes to investment, there must be a way to devide between type bounded or non-type bounded"*	6
E		Of KPI: *OPR*	A better way to to calculate OPR in early phases	No	3	*"OPR has been hard to measure in early phase"*	3
E		Of KPI: *Line utilization*	An easier way to calculate line utalization	No	3	*"Line utilization have been hard to measure"*	3
	Globalisation issues		**Global measurement alignment for running production**				
M		The different plants measure in different ways (in running production)	Alignment of measurement methods globally	No	3	*"China is not really documenting when they have rebalanced, different culture"*	3
E		Of KPI: *Investment* - Price lists is only valid in Europe	Revising price list so it it also suitable for China	No	3	*"Price lists is mainly for Europe, so it is difficult to see for e.g China. It is easy to find all data, we know the processes here."*	3
REPORTING							
	PSR issues		**Better reporting structure in PSR**				
TM BIW		Lack of targets	Having the KPIs in PSR with targets	No	3	*"PSR should have targets so it should be green but there is no right now."*	3
M, E		Ignorance of indicator colour	Implement a working indicator colour system with set routines	No	3	*"The bad thing about PSR is that if it shows red, we still continue forward"* *"I have got from my PM that I need to mark it as yellow, [no matter the result] there are we using it as an "indicator" how good we have been, not as improvement."*	6
	Lack of understanding		**Better communication procedurs**				
E		Of where the data ends up after it is reported	Better information of how the KPI results are used after they are reported	No	3	*""Where does the data end up after it is used? PSR? Is that good or bad? It is not very clearly. How does the feedback happen after the data is processed"*	3
E		Of how and to who the KPIs should be reported	Implement procedures and communicate reporting procedures	No	3	*"It takes a lot of time to understand how to report"*	3
	Missing features		**Adding certain reporting features**				
E		No comment possibility of KPI results	Possibility to add comment about the KPI results	No	3	*"I want to add info that is explaining more, that explains more why the number is now "Insert comment". What is hiding behind"*	3
	Measuring vs. reporting		**Diversiy between measuring and reporting**				
E		No difference between measurement phase and reporting phase today	Diversify between measuring phase (for improvement) and reporting phase (for controlling)	No	3	*"Today there is not really a difference between the measurement phase and when we report"*	3
PURPOSE MEASURABLES							
WHO	**WHAT**		**NEED**	**Impleme nted?**	"Need level"	**Examples**	
	For explaining aims		**Explanations**		FALSE		
TM ME, TM BIW, M		To motivate why the KPI results looks like they are	Data to explain why the KPI results looks like they look	Partly	2	*"They should explain total manufacturing costs, they should be connected to the KPIs to explain and give a bigger dimension"*	6
TM ME		Of KPI: manufacturing cost per car	Data to explain manufacturing cost per car in detail	Partly	2	*"They should explain total manufacturing costs, they should be connected to the KPIs to explain and give a bigger dimension"*	2
E	To define the KPIs		**The Measurables should define the KPIs**	No	3	*"We don't understand sqm cost. Get a better definition page with descriptions and explanations"*	3
PROBLEMS MEASURABLES							
WHO	**WHAT**		**NEED**	**Impleme nted?**	"Need level"	**Examples**	
	Distinctness from KPIs		**Clarify the distinctness from KPIs**				
E		Difference between KPIs and Measurables	Clear rules on what a KPI should be and what a measurable should be	No	3	*"Right now is the measurables almost like a KPI, difficult to read and understand from current list"*	3
	Ambiguous connection to KPIs		**Clarify the connection to KPIs**			*"They should explain total manufacturing costs, they should be connected to the KPIs to explain and give a bigger dimension"*	

E		Difficult to know how the Measurables are connected to the KPIs	Graphically show how the Measurables are connected to the KPIs	No	3	*"Measurables are used to understand and define, but it can be difficult to see the connection to the KPIs. You need to define target on certain measurables"*	**3**
	Lack of comparisions		**Target setting of the measurables**				
E		Relevant targets the Measurables results	Relevant and acheivable targets	No	3	*"Sometimes it feels like the targets are not set reasonable today"*	**3**
	Prioritization issues		**State clear prioritization list of the Measurables**				
M		Difficult to know which Measurable is most important	Prioritization list/weightening of the Measurables	No	3	*"Right now is the measurables almost a KPI, difficult to read from current list. We would like to have a order where the most important is highest, and what is connected to what"*	**3**
	Lack of understanding		**Better communication**				
E		Of the purpose of the Measurables	Better communication of the purpose of the Measurables	No	3	*"They are quite useless right now"*	**3**
E, PM		Of M: Amunt of robots	Better communication of why amount of robots is important	No	3	*"Amount of robots is a very dangerous number. Only management cares about it"* *"We should look into more manpower instead of robots, to questions what is good. To see on some stations, operations, perhaps can be manual work."*	**6**
GENERAL PMS RELATED							
PROBLEMS OVERALL							
WHO	**WHAT**		**NEED**	**Impleme nted?**	"Need level"	**Examples**	
	Lack of understanding of PP20 objectives		**Better understanding of PP20 implications**		FALSE		
TM BIW, M, E		Of which the PP20 objectives that affects BIW - Not FTT	Breaking down the PP20 objectives to BIW level	No	3	*"FTT is not a good measure for us"*	**9**
			Connecting BIW with running production				
TM ME, M, E	Lack of understanding how current state looks like today in running production		Better understanding of current state in running production	No	3	*"I think it is important that we can use the and connect the KPI and PMS to running production"* *"Data for the KPIs in running production is not known, for example square meter for a line. Is not measured"*	**9**
M, E		Little information of how current state is in running production	Mapping up KPI performance from running production	No	3	*"We want to have a lot of data so maybe we can see connections we haven't seen before"*	**6**
M, E		Difficulty to get proper data (from running production)	More, proper, data from running production	No	3	*"I have no idea how current performance are of my processes"* *"We need data so we later can look at correlations"*	**6**
M, E		No standard of how they are measuring in running production	Implement a standard measurement method at running production for the KPIs	No	3	*"The plant does not measure in a real clear way. There is not a standard. (They meauser things such as OPR, OEE)"*	**6**
	Lack of good communication		**Better communication**				
M, E		Lack of good communication channels/methods between running production and ME - No standard way of getting information about running production	Better communication channels/methods between ME and production (an easier way of getting data)	No	3	*"I need to speak to 10 different people to get the data, difficult to know if what they are saying is correct"*	**6**
E		Unserious feeling about the communication methods top management use to deliver messages	Top management should take communication more serious, and spend more time	No	3	*"Often we just get a picture [from management] of a whiteboard with a drawing, that doesn't feel serious"*	**3**
	Lack of alignment		**Better alignment**				
M		With each other	Alignment within BIW	No	3	*"If we are aligned it will help. We are often stuck in detail discussions."* *"A big problem is the integration between different commodity teams"*	**3**
M, E		From top management down to engineer level	Alignment from top management down to engineering level	No	3		**6**
	Company culture issues		**Better decision making culture**				
M, E		Decisions are taken based on feelings and old habits	To take decisions based on facts	Partly	2	*"We need to take decisions based on facts, not based on peoples feelings of what they think is the problem"*	**4**
	Prioritization issues		**State clear prioritization lists**				
M, E		Difficult to know what to prioritize in our work	Provide a prioritization lists/methods	No	3	*"Difficult to prioritize between the KPIs, what to focus on"*	**6**
E		Difficult to know what is expected of us to deliver for each gate	Provide a checklists for the different gates, connected to the KPIs / More gates with requirements	Partly	2	*"What we need is some kind of checklist, for our different gates. Connect to the gate, the KPIs to, and a checklist. But also connect to a way of working. Sometimes it is not always so clear. We need what should be delivered and when. Important to have a way of working, just not targets. A system, that overlooks the whole process, a checklist."*	**2**
	Short-run thinking		**Thinking in a long-run perspective**				
E		Engineers finds that short-running issues is Volvo biggest focus	Change perspective from short-run to long-run perspective	Partly	2	*"A problem is that we not thinking of the long run. Sometimes it is not always the best to take the lowest cost, ex. supplier that is the lowest cost not the best."*	**2**
	Lack of knowledge						
E		Within the field of manual operations	More knowledge/competency within cerain fields: - Manual operations	No	3	*"Manual line is not being involved. SME, Subject matter expert, we need more of them, on the technical side of ME. We are lagging on tech side, especially on manual operations"*	**3**

C

Appendix - KPI Tree



REMARKS:
A more detailed breakdown of the tree can be found on the two following pages.
Note: ”N/A”: Not Applicable.
Page numbers (p.) refers to Volvo Cars Annual Report 2018

CORPORATE LEVEL – CORPORATE		CORPORATE OBJECTIVES			M&L LEVEL – M&L OBJECTIVES			ME LEVEL – ME OBJECTIVES	
Strategic Purpose	***Strategic steps***	**Corporate focus areas**	**Affects M&L?**	**Affects M&L how - Priority action**	**Theme**	**Top Level Perf. Objectives**	**Mission**	**Higher-level Perf. Objectives**	**Task**
SUSTAINABLE	TRULY GLOBAL PRESENCE	Have a naturally hedged global production (p. 22)	YES	Need for lean transformation	**FUTURE & SHAREHOLDERS**	**LEAN PROCESS DESIGN**	Excel in lean	LEAN PROCESSES	Implement lean fundamental principles Implement ideal state thinking
SUSTAINABLE	STANDALONE GOVERNANCE & STRENGTHEN BRAND	Acheive a superior growth (p. 22)	YES	Need for increased production capacity	**FUTURE & SHAREHOLDERS**	**INDUSTRALIZA TION**	Excel in launch abilities	LAUNCHING	Handle needed capacity
SUSTAINABLE	STANDALONE GOVERNANCE & STRENGTHEN BRAND	Increase subscriptions with recurring revenue (p. 22)	NO		**FUTURE & SHAREHOLDERS**				
SUSTAINABLE	SUSTAINABLE PRODUCT AND BUSINESS	Acheive the highest standard of sustainability (p. 21)	YES	Need for improving waste management processes (material recycling) (p. 61)	**FUTURE & SHAREHOLDERS**	**ENVIRONMENT**	Increase amount of reused resources	REUSED ASSETS	Increase amount of reused machines
SUSTAINABLE	SUSTAINABLE PRODUCT AND BUSINESS	Acheive the highest standard of sustainability (p. 21)	YES	Need for focusing on reducing energy consumption (p. 60)	**FUTURE & SHAREHOLDERS**	**ENVIRONMENT**	Reducing CO2 footprint	ENERGY CONSUMPTION	Minimize the energy consumption
SUSTAINABLE	SUSTAINABLE PRODUCT AND BUSINESS	Acheive the highest standard of sustainability (p. 21)	NO		**FUTURE & SHAREHOLDERS**				
SUSTAINABLE	SUSTAINABLE PRODUCT AND BUSINESS	Acheive premium profitability (p. 22)	YES	Need for decreasing costs	**FUTURE & SHAREHOLDERS**	**FINANCIALS**	Reduce costs	**FINANCIALS**	Minimize manufacturing costs
SUSTAINABLE	PURPOSE DRIVEN ORGANISATION	Obtaining a high human centricy focus (p. 33)	YES	Need for increased focus on diversification and gender equality	**EMPLOYEES**	**PEOPLE DEVELOPMENT**	Develop managers	LEADERSHIP	International leader diversification Acheive gender equality
SUSTAINABLE	PURPOSE DRIVEN ORGANISATION	Obtaining a high human centricy focus (p. 33)	YES	Need for focusing on the well-being on both M&L and plant employees	**EMPLOYEES**	**PEOPLE DEVELOPMENT**	Develop employees	DEVELOP WHITE COLOUR MEMBERS	Empower people High well-being and drive for the job
SUSTAINABLE	PURPOSE DRIVEN ORGANISATION	Obtaining a high human centricy focus (p. 33)	YES	Need for driving purpose-driven leadership culture	**EMPLOYEES**	**PEOPLE DEVELOPMENT**	Develop employees	DEVELOP WHITE COLOUR MEMBERS	Efficiency in daily tasks
SAFE	PURPOSE DRIVEN ORGANISATION	Pioneer for the safest solutions (p. 22)	YES	Need for highest standards of safety for people working in the plant	**EMPLOYEES**	**SAFETY**	Ensure that people is working in a safe way	**SAFETY**	Minimize risk for accidents
SAFE	SAFETY MOBILITY WITH LEADING AD TECHNOLOGY	Pioneer for the safest solutions (p. 22)	YES	Need highest standard of quality of manufacturing operations	**CUSTOMERS**	**QUALITY**	Excel in car quality	**QUALITY**	Minimize defects/vehicle
PERSONAL	COMPLETELY NEW VEHICLE RANGE	Build the most personal solutions (p. 21)	YES	Need for increased capacity for product complexity Need for increased capacity for product variant flexability	**CUSTOMERS**	**DELIVERY**	Flow in production processes	**FLOW / SUPPLY-CHAIN**	Minimize lead-time Minimize tied-up capital
PERSONAL	COMPLETELY NEW VEHICLE RANGE	Build the most personal solutions (p. 21)	YES		**CUSTOMERS**	**DELIVERY**	Flow in production processes	FLEXIBILITY	Become more flexible
PERSONAL	COMPLETELY NEW VEHICLE RANGE	Increase amount of pure electric cars (p. 22)	YES		**CUSTOMERS**	**DELIVERY**	Stability in operations	ROBUSTNESS	Create more robust processes
PERSONAL	COMPLETELY NEW VEHICLE RANGE	Increase amount of autonomous cars (p. 22)	YES		**CUSTOMERS**	**DELIVERY**	Stability in operations	ROBUSTNESS	Create more robust processes
PERSONAL	PERSONAL AND DIRECT RELATIONSHIPS WITH CONSUMER	Increase direct consumer relations (p. 22)	NO		**CUSTOMERS**				

BIW OBJECTIVES

BIW LEVEL

Performance Objectives	Task	Action	Indicator(s)	Exists today?	Comments & Recommendation
BODY FUNDAMENTALS	***Strategy:*** *Implement Body Fundamentals and Lean KPIs*				**Recommendation**: put extra efforts on education in lean principles
IDEAL STATE	***Strategy:*** *Use the ideal state concept to close current gaps*				**Recommendation**: put extra efforts on ideal state definition and make a closer connection between the gaps and the KPIs
CAPACITY	Install full capacity from start (all models)*		N/A	**No**	
	Invest in higher capacity than customer demand*	0-20% overcapacity on non-flexible lines	N/A	**No**	
REUSED MACHINES	Increase amount resused machines		**Investigate**	**No**	**Comment:** potentially an area for future performance measurement
ENERGY CONSUMPTION	Minimize energy consumption	Minimize amount of robots?	**Investigate**	**No**	**Comment:** potentially an area for future performance measurement
LIFECYCLE COSTS	Minimize costs	Minimize total manufacturing costs	- Total Mfc/car	Yes	**Recommendation:** Look into a more detailed total view of Mfc/car, inclusing energy consumption, logistics, indirect manning etc.
INVESTMENTS	Minimize investments		- Investment	Yes	
DIVERSIFICATION	Increase diversification of international leaders	Focus on people progress - team level - personal level	**Invesigate**	**No**	**Recommendation:** Investigate Performance Measurements possibilities for *People Development*
GENDER EQUALITY	Increase the gender equality of leaders			**No**	
FEELING OF RESPONSIBILITY	Acheive a high well-being and drive for the job			**No**	
WELL-BEING					
EFFICIENCY IN PROCESS DESIGN	Make the process design process more efficient (spend less time)				
ERGONOMICS	Prevent injuries for the operator	Ergonomic workstations designed according to VCS 8003,29 (Ergonomic requirements)	- Ergonomics	Yes	**KPI Suggestion:** Make Egonomics to a KPI (%)
	Having the same picking place for the part, to the operator	The part is always in the same picking position for the operator	N/A	**No**	
SAFETY RISKS	No injuries for the operator	No dangerous stations	**Investigate**	**No**	**Recommendation:** investigate performance measurement for *safety*
		Operators grouped close to each other (in order to be able to help if somethig happens)	**Investigate**	**No**	**Recommendation**: investigate performance measurement for *Isolated islands*
GEOMETRY ASSURANCE	Reduce geometric variation	Use one set of geometric setting fixtures / equipment	**Investigate**	**No**	**Recommendation**: investigate performance measurement for *single tooling*
		Common handling points for all platforms	**Investigate**	**No**	**Recommendation**: investigate performance measurement for *handling point*
ALIGNMENT BETWEEN DEPARTMENT	***Strategy:*** *Align KPIs between departments*				**Recommendation:** Investigate alignment with other departments
PROCESS FLOW COMPLEXITY	Avoid long transports of big parts inside the plant	Optimize the used squaremeter space	- Sqm	Yes	
	Avoid unnecessary internal transport of parts	Optimize the used squaremeter space			
	CMA amd SPA produced at different sites		N/A	**No**	
	Adding variants specific characteristics as late as possible		N/A	**No**	
	Stations and material infeed disconnected from mainline		N/A	**No**	
	Easy overview and understanding of the process flow		N/A	**No**	
	All products follows the same build sequency	One common BOP per each platform*	N/A	**No**	
	Mainly value-adding (and neceserry non-value) work		**Investigate**	**No**	**KPI Suggestion:** Modifaction of Operator Utilization to (VA + NNVA) / Cycle time
EFFICIENCY	Increase operator utilization		Operator utilization	Yes	
	Decrease Machine Maintainance		**Investigate**	No	**Recommendation**: Investigate possible performance measurement - **MTTR?**
	Increase line utilization		Line utilization	Yes	
	Increase machine utilization		Machine utilization	Yes	
PULL PRINCIPLE	Deliver just-in-time		**Investigate**	**No**	**Recommendation**: Investigate possible performance measurement - **WIP?**
VARIANT FLEXIBILITY	Be able to quickly change to produce new variants/products		**Investigate**	**No**	**Comment:** potentially an area for future performance measurement
ASSEMBLY TYPE FLEXIBILITY	Being able to change from/to automatic to/from manual assembly		**Investigate**	**No**	**Comment:** potentially an area for future performance measurement
VOLUME FLEXIBILITY	Produce at both low and high volume	Enable of operators to following line speed when the capacity demand is changing	- Mantime flexibility	Yes	
SET-UP & TAKE-DOWN FLEXABILITY	Easy set-up and take-down of installed equipment (also connected to "Launching above")		**Investigate**	**No**	**Comment:** potentially an area for future performance measurement **Recommendation**: Investigate concepts such as **modular factory**
RELIABILITY	***Strategy:*** *All process solutions has been verified before implementation**				**Recommendation:** Use existing and "proven" solutions, rather than new not tested solution
	Enable low MTTR	Easy access to the equipment	N/A	**No**	
	Have a reliable process with low risk for stops / low risk for long stop-times	Create an environment with low risk for failures/stops	- Amount of robots?	Yes	**Recommendation:** Use existing and "proven" solutions, rather than new not tested solution. Look at type of robots?
AVAILABILITY	The workload is evenly distributed and optimized	Produce at a stable takt time in the process	- Line technical Availability	Yes	